INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE KRD-4 DIRECTIONAL OVERCURRENT GROUND RELAY

CAUTION: Before putting relays into service, remove all blocking which may have been inserted for the purpose of securing the parts during shipment, make sure that all moving parts operate freely, inspect the contacts to see that they are clean and close properly, and operate the relay to check the settings and electrical connections.

APPLICATION

The KRD-4 relay is a high speed directional overcurrent relay which is used for the protection of transmission lines and feeder transmission lines and feeder circuits. These relays are dual polarized relays which can be polarized from a potential source, from a local ground source, or from both simultaneously.

They are also used, without modifications to provide directional ground fault protection in the KD-4 carrier relaying scheme. Operation of the relays in connection with the carrier scheme is fully described in I.L. 41-911.

CONSTRUCTION

The type KRD-4 directional overcurrent ground relay consists of a dual polarized directional unit, an instantaneous overcurrent unit, and an indicating contactor switch. The principal parts of the relay and their location are shown in Fig. 1 to 3.

A. DIRECTIONAL UNIT (D)

The directional unit of the KRD-4 consists of an induction cylinder unit, phase shifting network, and a de-coupling network.

1. Induction Cylinder Unit

The cylinder unit is a product type in which torque is produced by the phase relationship of an operating flux and a polarizing flux on an aluminum cylinder supporting a moving contact arm. A contact opening torque or a contact closing torque is produced depending upon the phase relationship between the two fluxes.

The cylinder unit consists of three basic assemblies: an electromagnet assembly, a moving element assembly, and a stationary closing assembly.

The electromagnet assembly consists of an electromagnet, an adjustable magnetic core, two magnetic adjusting plugs, lower bearing pin, and a die-casted aluminum frame. The moving element assembly consists of a spiral spring, contact carrying member, and an aluminum cylinder which is assembled to a molded hub which holds the shaft. The shaft has removable top and bottom jewel bearings. The stationary contact assembly consists of a molded bridge, upper bearing pin, stationary contact housing and spring adjuster is located on the underside of the bridge and is held in place by a spring type clamp. It is attached to the moving contact arm by a spiral spring.

The electromagnet has four poles, two operating poles and two polarizing poles. Each pair of poles are diametrically opposite each other and are excited by series connected coils. (Two sets of series connected coils are used to excite the polarizing poles, one set for current polarizing and the other set for voltage polarizing). The electromagnet is permanently mounted to the frame in such a manner that an air gap exists between the pole faces of the electromagnet and the magnetic core. The aluminum cylinder of the moving element assembly rotates in this air gap on the upper and lower pin bearing.

With the contacts closed, the electrical connection is made through the stationary contact housing clamp, then the moving contact, through the spiral spring out to the spring adjusted clamp.

2. Phase Shifting Network

The phase shifting network consists of a resistor, capacitor and reactor in the polarizing circuit of the directional unit, and a saturable shunt in the operating circuit.

3. De-Coupling Network

The de-coupling network consists of an air gap

SUPERSEDES I.L. 41-137.3C
*Denotes change from superseded issue.

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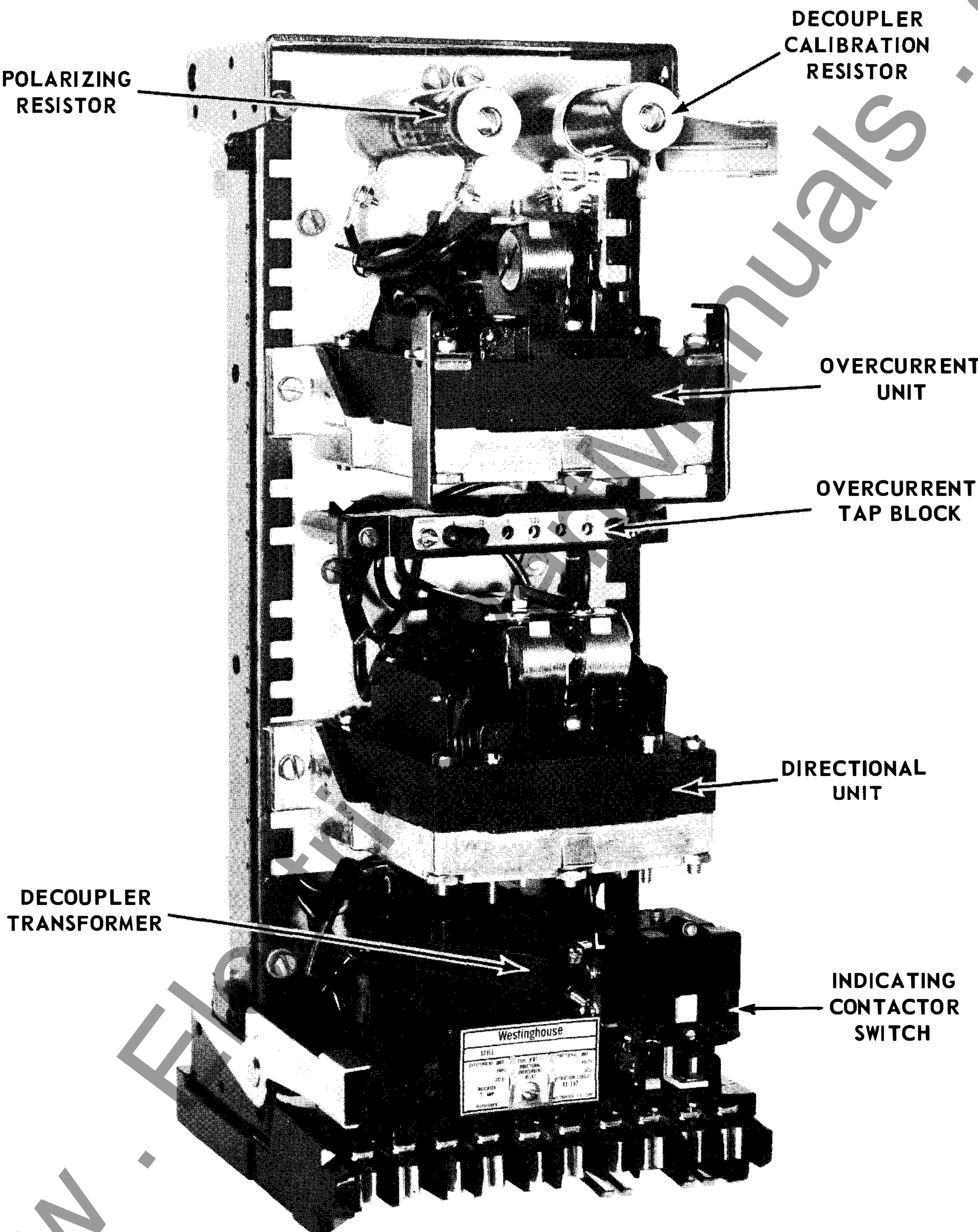


Fig. 1. Type KRD-4 Relay (Front View).

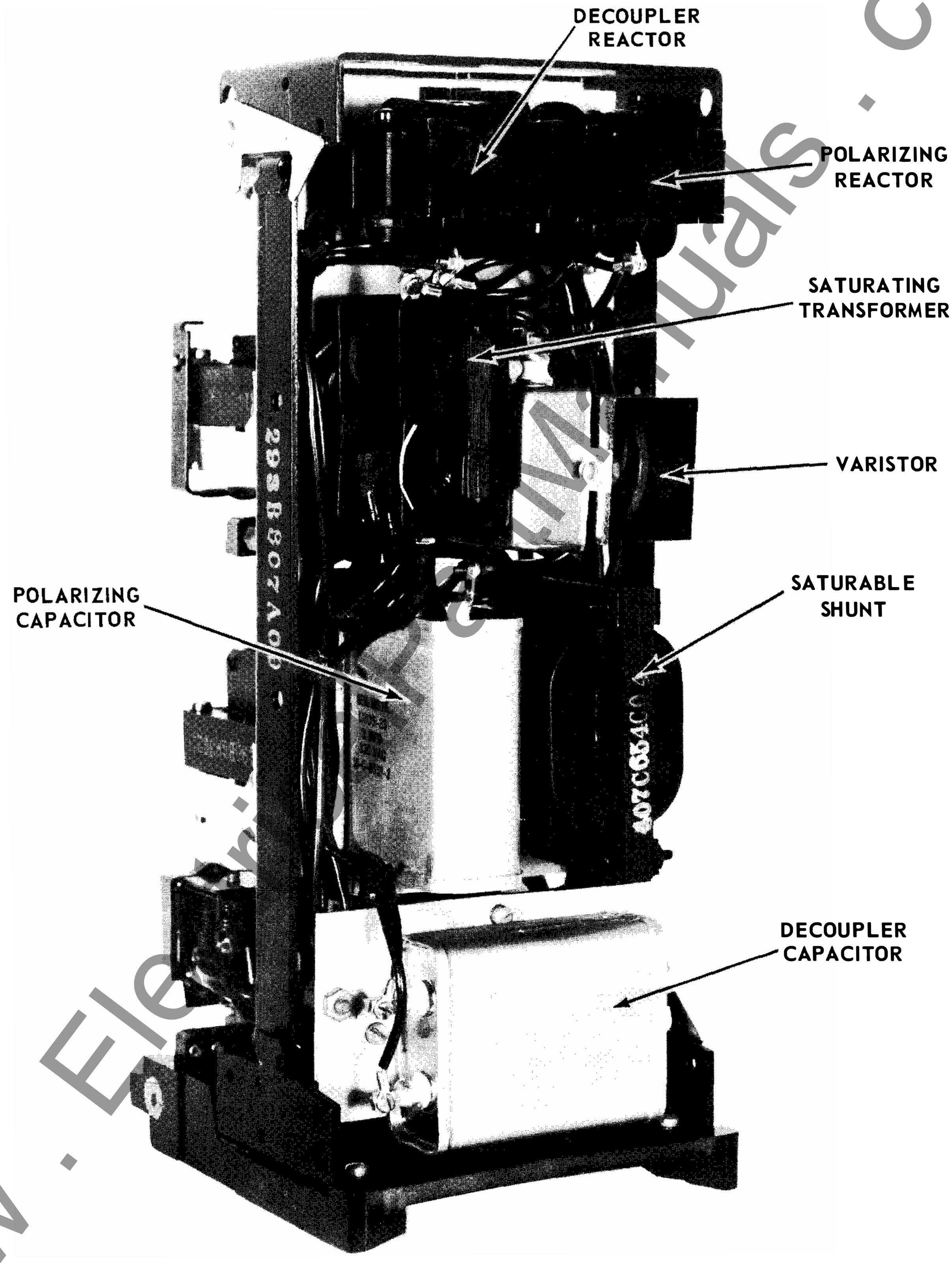


Fig. 2. Type KRD-4 Relay (Rear View).

transformer, capacitor, reactor, and resistor. Electrically this network is equivalent to the polarizing circuit of the induction cylinder unit and is utilized to minimize the coupling between the current and potential polarized sources.

B. INSTANTANEOUS OVERCURRENT UNIT (I)

The instantaneous overcurrent unit consists of an induction cylinder unit, capacitor, varistor, and a transformer. The components are connected such that a contact closing torque is produced when the current exceeds a specified value.

1. Cylinder Unit

The cylinder unit is similar in construction to the cylinder unit of the directional unit except that all coils are similar. The phase relationship of the two air gap fluxes necessary for the development of torque is achieved by means of a capacitor connected in series with one pair of pole windings.

2. Transformer

The transformer is a saturating type consisting of a tapped primary winding and a secondary winding. A varistor is connected across the secondary winding to reduce the voltage peaks applied to the cylinder unit and phase shifting capacitor.

C. INDICATING CONTACTOR SWITCH (ICS)

The indicating contactor switch is a small d-c operated clapper type device. A magnetic armature to which leaf-spring mounted contacts are attached, is attracted to the magnetic core upon energization of the switch. When the switch closes, the moving contacts bridge two stationary contacts, completing the trip circuit. Also during this operation two fingers on the armature deflect a spring located on the front of the switch, which allows the operation indicator target to drop. The target is reset from outside of the case by a push rod located at the bottom of the cover.

The front spring, in addition to holding the target, provides restraint for the armature and thus controls the pickup value of the switch.

OPERATION

The type KRD-4 relay is connected to the protected transmission line as shown in Fig. 4. In such a connection, the relay operates to disconnect the line for ground faults of a definite magnitude that are flowing in a specified direction.

The directional unit of the relay compares the phase angle between the fault current and the polarizing quantities of the system and either produces a contact closing torque for faults in the trip direction or produces a contact opening torque for faults in the non-trip direction. Relay operation occurs when both the directional unit and the instantaneous overcurrent unit close their contacts. Hence, the fault current must be greater than the tap setting of the overcurrent unit.

For faults in the non-trip direction, a contact opening torque is produced by the directional unit such that the normally closed contact of this unit shorts out a pair of windings on the overcurrent unit. This prevents the overcurrent unit from developing torque to close its contacts. For faults in the trip direction, the directional unit will pickup and remove this short circuit, allowing the overcurrent contact to commence closing almost simultaneously with the directional contact for high speed operation.

CHARACTERISTICS

The relays are available in the following current ranges:

Range	Taps					
0.5-2 Amps.	0.5	0.75	1.0	1.25	1.5	2
1-4	1.0	1.5	2.0	2.5	3.0	4.0
4-16	4.0	6.0	8.0	9.0	12	16
10-40	10	15	20	25	30	40

The tap value is the minimum current required to just close the overcurrent relay contacts. For pickup settings in between taps refer to the section under SETTINGS.

The KRD-4 relay is designed for dual polarizing and can be polarized from a potential source, a local ground source or from both simultaneously. When the relay is potential polarized, the maximum torque of the relay occurs when the operating current lags the polarizing voltage by approximately 65 degrees. When the relay is current polarized, the maximum torque of the relay occurs when the operating current is in phase with the polarizing current.

TIME CURVES

The time curves for the KRD-4 relay are shown in Fig. 5 and 6. Fig. 5 includes three curves which are:

1. Directional Unit opening times for current, voltage, or dual polarized.
2. Directional unit closing times for current, voltage or dual polarized.
3. Directional unit closing time for 5 volts voltage polarized.

Fig. 6 shows the instantaneous overcurrent unit closing time.

The voltage polarized curve (curve B in Fig. 5) begins to deviate from curve A at about 10 volts polarization.

Both the directional unit and the overcurrent unit must operate before the trip circuit can be completed. Hence, the unit which takes the longer time to operate determines when the breaker will be tripped. The overcurrent unit contacts cannot operate until the back contacts of the directional unit open; therefore, the total time for the overcurrent unit to operate is its closing time given in Fig. 6 plus the directional unit's opening time given in Fig. 5. The total closing time for the directional unit is given in Fig. 5. The two examples below will serve to illustrate the use of the curves.

(Example One) definition of symbols are shown on Fig. 5.

let: I_{pol} = 1.5 amp.
I_{op} = 3 amp
tap value (T) = 0.5 amp.
$\emptyset = 0°$

for a current polarized relay:

$$* \quad MPP = \frac{I_{op} I_{pol} \cos \emptyset}{0.25}$$

$$* \quad MPP = \frac{(3)\ (1.5)}{0.25} = 18$$

Entering the curves in Fig. 5 at multiples of product pickup of 18 the directional unit opening time is 4 ms, and the closing time for this unit is 33 ms.

For the overcurrent unit:

$$\text{multiples of pickup} = \frac{I_{op}}{T} = \frac{3}{0.5} = 6$$

Entering the curve in Fig. 6 at multiples of pickup equal to 6 the closing time for the overcurrent is 14 ms. However, the total operating time for the overcurrent unit is 14 plus 4 ms, which is the opening time of back contacts of the directional unit, or 18 ms total operating time for the overcurrent unit. The total operating time for the directional unit is 33 ms; and since this is the longest time, 33 ms is the total operating time of the relay.

(Example Two)

let: I_{pol} = 15 amp
I_{op} = 25 amp
T (tap) = 1 amp.
$\emptyset = 0$

$$MPP = \frac{I_{op} I_{pol} \cos \emptyset}{0.25}$$

$$MPP = 1500$$

referring to Fig. 5 the directional unit closing time is 8 ms, and the opening time of its back contacts is 3 ms. The total operating time for the directional unit is 8 ms.

For the overcurrent unit:

$$\text{multiples of pick up} = \frac{I_{op}}{T} = 25$$

referring to Fig. 6 the overcurrent unit contact closing time is 10 ms. Therefore, the total operating time for this unit is 10 + 3 ms or 13 ms. In this case the total operating time of the relay is 13 ms.

Trip Circuit

The main contacts will safely close 30 amperes at 250 volts d-c and the seal-in contacts of the indicating contactor switch will safely carry this current long enough to trip a circuit breaker.

The indicating contactor switch has a pickup of approximately 1 ampere. Its d-c resistance is 0.1 ohms.

Cylinder Unit Contacts

The moving contact assembly has been factory adjusted for low contact bounce performance and should not be changed.

The set screw in each stationary contact has been shop adjusted for optimum follow and this adjustment should not be disturbed.

* TABLE I

DIRECTIONAL UNIT SENSITIVITY

Polarizing Quantity	Values for Min. Pickup		Phase Angle Relationship
	Volts	Amperes	
VOLTAGE	1	0.7	I lagging V by 65°
	1	1.5	I In Phase with V
CURRENT		0.5	In-phase

The energization quantities are input quantities at the relay terminals. Maximum torque angle.

TABLE II

DIRECTIONAL UNIT CALIBRATION

Relay Rating	Current Amperes	Both Plugs In Condition	Adjustment
All Ranges	80	Spurious torque in contact closing direction (left front view)	Right (front view Plug Screwed out until spurious torque is reversed.
All Ranges	80	Spurious torque in contact opening direction (Right front view) (Contact remain Open)	Left (front view) Plug screwed out until spurious torque is in contact closing directions. Then the plug is screwed in until spurious torque is reversed.

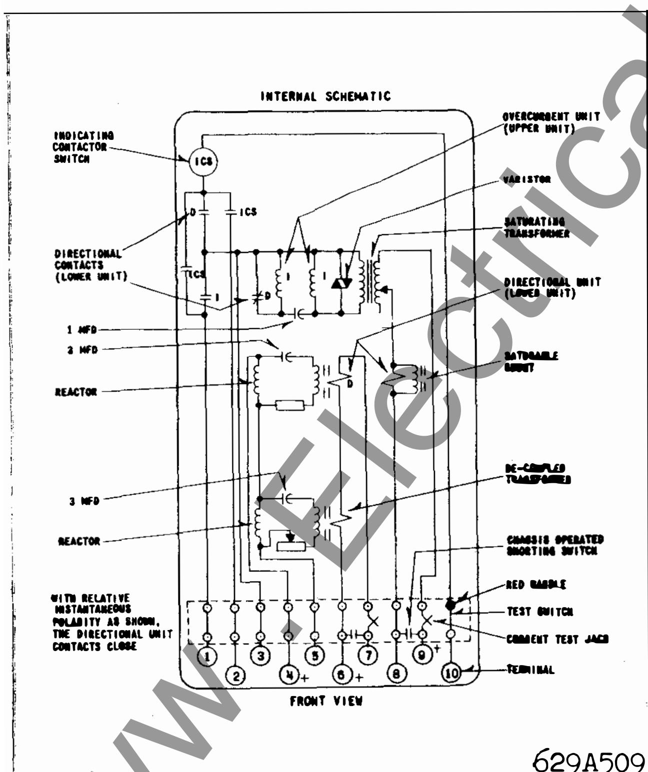


Fig. 3. Internal Schematic of the Type KRD-4 Relay in the Type FT31 Case.

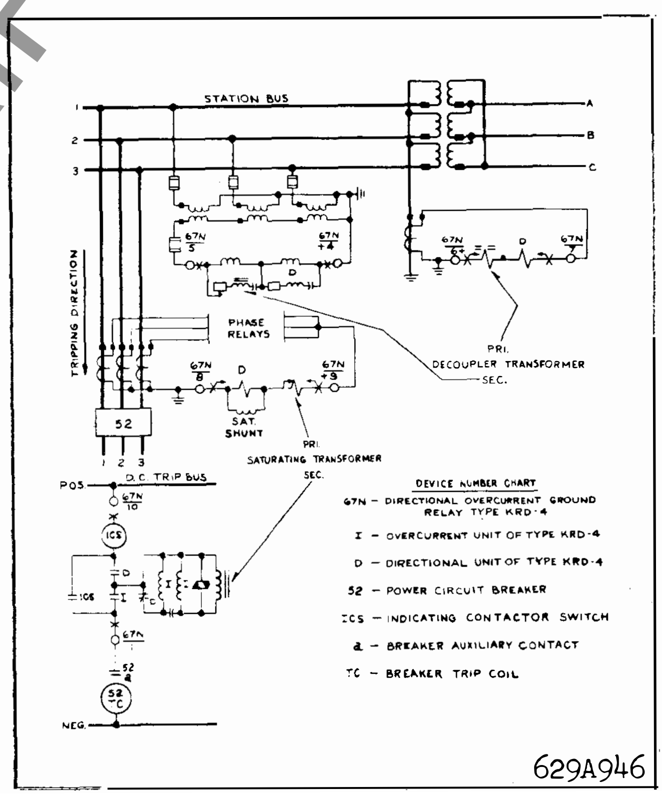


Fig. 4. External Schematic for the Type KRD-4 Relay.

SETTINGS

Overcurrent Unit (I)

The only setting required is the pickup current setting which is made by means of the connector screw located on the tap plate. By placing the connector screw in the desired tap, the relay will just close its contacts at the tap value current.

If adjustment of pick-up current in between tap settings is desired insert the tap screw in the next lowest tap setting and adjust the spring as described. It should be noted that this adjustment results in a slightly different time characteristic curve and burden.

For carrier relaying the carrier trip overcurrent unit located in the type KRD-4 relay should be set higher than the carrier start overcurrent unit located in the type KA-4 relay at the opposite end of the line.

CAUTION: Since the tap block connector screw carries operating current, be sure that the screw is turned tight.

In order to avoid opening the current transformer circuits when changing taps under load, connect the spare tap screw in the desired tap position before removing the other tap screw from the original tap position.

ENERGY REQUIREMENTS

BURDEN DATA OF OPERATING CURRENT CIRCUIT – 60 CYCLES

AMPERE RANGE	TAP	VA AT TAP VALUE	P.F. ANGLE Ø	VA AT 5 AMPS	P.F. ANGLE Ø
.5-2	.5	.23	54°	47	52°
	.75	.52	54°	36	52.5°
	1.0	.94	54°	31	53°
	1.25	1.56	54°	28	53.5°
	1.5	2.17	54°	26.5	54°
	2.0	3.88	54°	24	55°
1-4	1.0	1.3	52°	31.5	51°
	1.5	2.85	52°	27.3	51.5°
	2.0	5.2	52°	25.0	52°
	2.5	7.75	52°	24.2	52.5°
	3.0	11.4	52°	23.8	53
	4.0	10.6	52°	23.3	53.5°
4-16	4	5.6	43°	610†	53°
	6	10.8	46°	570†	54°
	8	17.6	47°	560†	54°
	9	22.5	48°	550†	55°
	12	39.5	50°	550†	56°
	16	69	52°	550†	56°
10-40	10	28	49°	545†	50°
	15	61	51°	540†	51°
	20	108	53°	535†	52°
	25	169	54°	530†	53°
	30	252	56°	525†	53°
	40	432	57°	525†	53°

† VA at 50 Amperes.

DIRECTIONAL UNIT POLARIZING CIRCUIT BURDEN

CIRCUIT	RATING	VOLT AMPERES△	POWER FACTOR ANGLE Ø
Current	230†† amperes	1.20	3° Lag
Voltage	208††† volts	21.0	28° Lead

Ø Degrees current leads or lags voltage at 120 volts on voltage polarized units and 5 amperes on current polarized units.

△ Burden of voltage polarized unit taken at 120 volts. Burden of current polarized units taken at 5 amperes.

†† One second rating.

††† 30 second rating. The 10 second rating is 345 volts. The continuous rating is 120 volts.

Directional Unit (D)

No setting is required.

INSTALLATION

The relays should be mounted on switchboard panels or their equivalent in a location free from dirt, moisture, excessive vibration and heat. Mount the relay vertically by means of the two mounting studs for projection mounting or by means of the four mounting holes on the flange for the semi-flush mounting. Either of the studs or the mounting screws may be utilized for grounding the relay. The electrical connections may be made directly to the terminals by means of screws for steel panel mounting or to terminal studs furnished with the relay for thick panel mounting. The terminal studs may be easily removed or inserted by locking two nuts on the studs and then turning the proper nut with a wrench.

For detailed information, refer to I.L. 41-076.

ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory. Upon receipt of the relay, no customer adjustments, other than those covered under "SETTINGS," should be required.

Acceptance Check

The following check is recommended to insure that the relay is in proper working order.

Overcurrent Unit (I)

1. Contact Gap - The gap between the stationary and moving contacts with the relay in the de-energized position should be approximately .020."
2. Minimum Trip Current - The normally-closed contact of the directional unit should be blocked open when checking the pick-up of the overcurrent unit.

   The pick-up of the overcurrent unit can be checked by inserting the tap screw in the desired tap hole and applying rated tap value current. The contact should close with ±5% of tap value current.

Directional Unit (D)

1. Contact Gap - The gap between the stationary contact and moving contact with the relay in the de-energized position should be approximately .020."
2. Sensitivity - The respective directional units should trip with value of energization and phase angle relationships as indicated in Table 1.
3. * Spurious Torque Adjustments — There should be no spurious closing torques when the operating circuits are energized per Table 2.
4. Coupling - Apply 20 amperes to terminals 6 and 7. Measure voltage across terminals 4 and 5. Should be less than 20 volts.

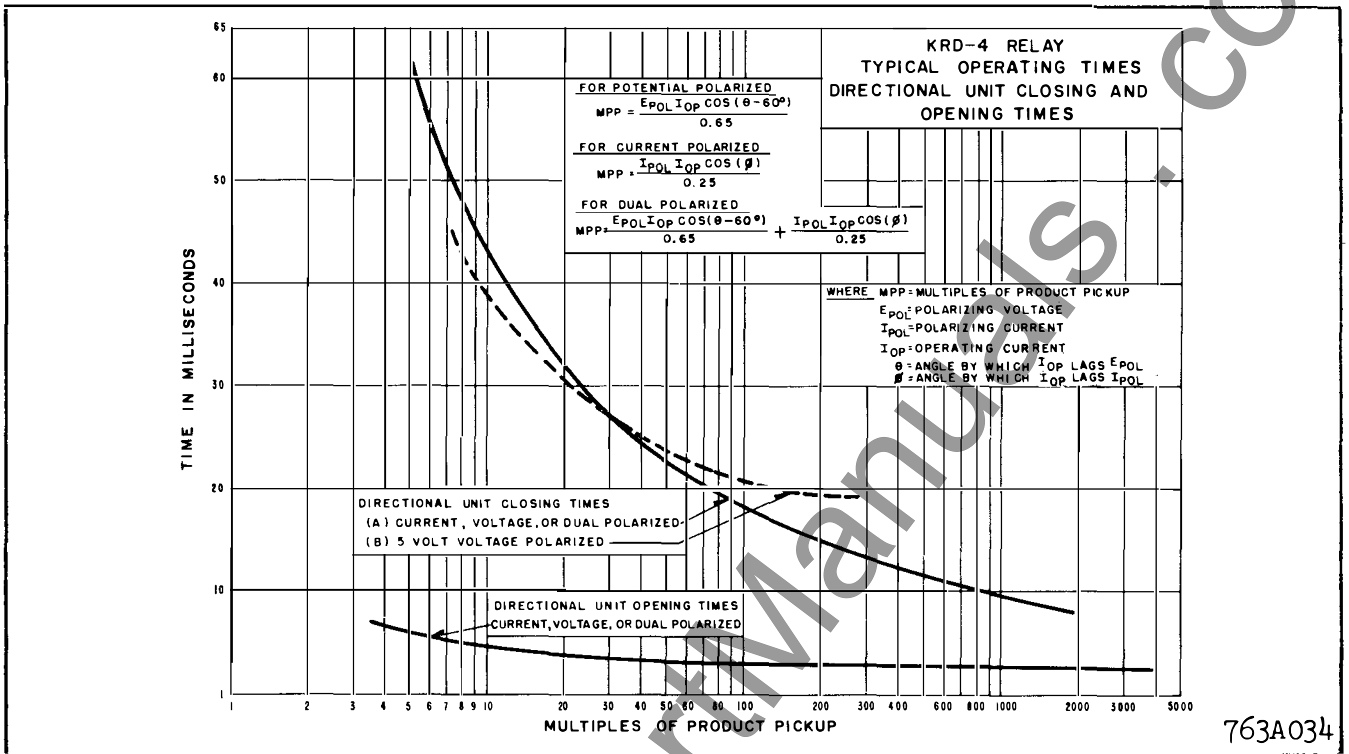


Fig. 5. Typical Time Curves for the Directional Unit.

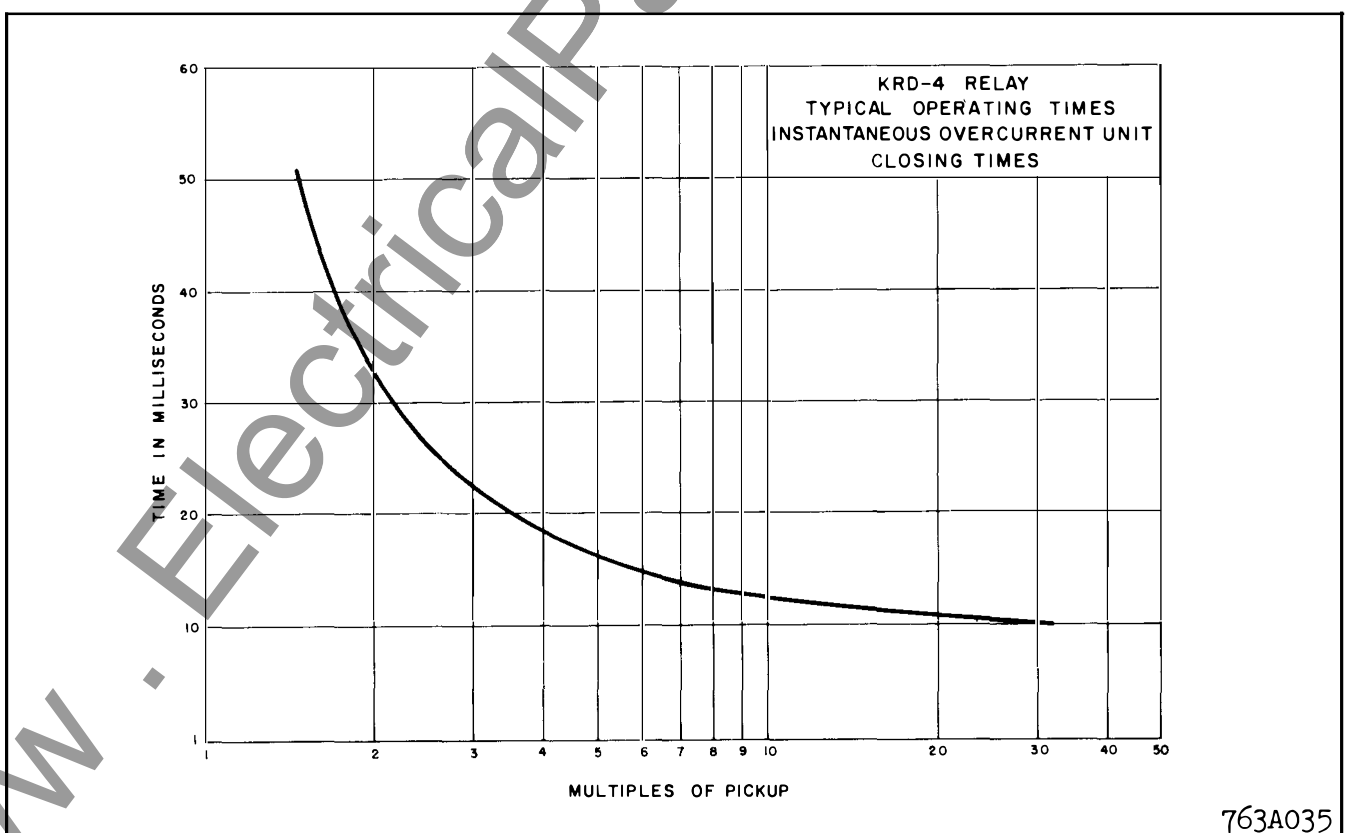


Fig. 6. Typical Time Curves for the Instantaneous Overcurrent Unit.

Indicating Contactor Switch (ICS)

Close the main relay contacts and pass sufficient d-c current through the trip circuit to close the contacts of the ICS. This value of current should be between 1 and 1.2 amperes. The indicator target should drop freely.

The contact gap should be approximately 5/64'' between the bridging moving contact and the adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously.

ROUTINE MAINTENANCE

All relays should be inspected periodically and the operation should be checked at least once every year or at such other time intervals as may be dictated by experience to be suitable to the particular application.

All contacts should be periodically cleaned. A contact burnisher S#182A836H01 is recommended for this purpose. The use of abrasive material for cleaning is not recommended because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact.

Calibration

Use the following procedure for calibrating the relay if the relay has been taken apart for repairs or the adjustments have been disturbed. This procedure should not be used unless it is apparent that the relay is not in working order. (See "Acceptance Check").

Overcurrent Unit (I)

1. The upper pin bearing should be screwed down until there is approximately .025 clearance between it and the top of shaft bearing. The upper pin bearing should then be securely locked in position with the lock nut. The lower bearing position is fixed and cannot be adjusted.

2. The contact gap adjustment for the overcurrent unit is made with the moving contact in the reset position, e.g., against the right side of the bridge. Advance the stationary contact until the contacts just close. Then back off the stationary contact 2/3 of one turn for a gap of approximately .020''. The clamp holding the stationary contact housing need not be loosened for the adjustment since the clamp utilizes a spring-type action in holding the stationary contact in position.

3. The sensitivity adjustment is made by varying the tension of the spiral spring attached to the moving element assembly. The spring is adjusted by placing a screwdriver or similar tool into one of the notches located on the periphery of the spring adjuster and rotating it. The spring adjuster is located on the underside of the bridge and is held in place by a spring type clamp that does not have to be loosened prior to making the necessary adjustments.

Before applying current, block open the normally-closed contact of the directional unit. Insert the tap screw in the minimum value tap setting and adjust the spring such that the contacts will close as indicated by a neon lamp in the contact circuit when energized with the required current. The pick up of the overcurrent unit with the tap screw in any other tap should be within ±5% of tap value.

Directional Unit (D)

1. The upper bearing screw should be screwed down until there is approximately .025 clearance between it and the top of the shaft bearing. The upper pin bearing should then be securely locked in position with the lock nut.

2. **Contact Gap.** Adjustment for the directional unit is made with moving contact in the reset position, i.e., against the right side of the bridge. Advance the right hand stationary contact until the contacts just close. Then advance the stationary contact an additional one-half turn.

Now move the in the left-hand stationary contact until it just touches the moving contact. Then back off the stationary contact 2/3 of one turn for a contact gap of approximately .020''. The clamp holding the stationary contact housing need not be loosened for the adjustment since the clamp utilizes a spring-type action in holding the stationary contact in position.

3. **Sensitivity.** Insert tap screw of overcurrent unit in highest tap. The sensitivity adjustment is made by varying the tension of the spiral spring attached to the moving element assembly. The spring is adjusted by placing a screwdriver or similar tool into one of the notches located on the periphery of the spring adjuster and rotating it. The spring adjuster is located on the underside of the bridge and is held in place by a spring type clamp that does not have to be loosened prior to making the necessary adjustments.

* The spring is to be adjusted such that the contacts will close with .5 amperes flowing into terminal 6 and out terminal 8 with terminals 7 and 9 jumped together. (Use 0.7 Amps for 4-16 and 10-40 Amps.)

4. **De-Coupling Adjustment.** Connect high resistance, low reading voltmeter across terminals 4 and 5. Pass 80 amperes into terminals 6 and 7 and adjust top right hand resistor (front view) until a minimum voltage is obtained. Use care not to overheat relay during test.

5. **Core Adjustment.** Apply 10 amperes to terterminals 8 and 9 with all other terminals open circuited. Adjust core such that the contacts remain open. The core can be adjusted by the use of a screwdriver in the slots in the bottom of the cylinder unit.

6. **Plug Adjustment.** Apply current to terminals 8 and 9 with all other terminals open circuited. Plug adjustment is then made per Table II such that the spurious torques are reversed. The plugs are held in position by upper and lower plug clips. These clips need not be disturbed in any manner when making the necessary adjustment.

Indicating Contact Switch (ICS)

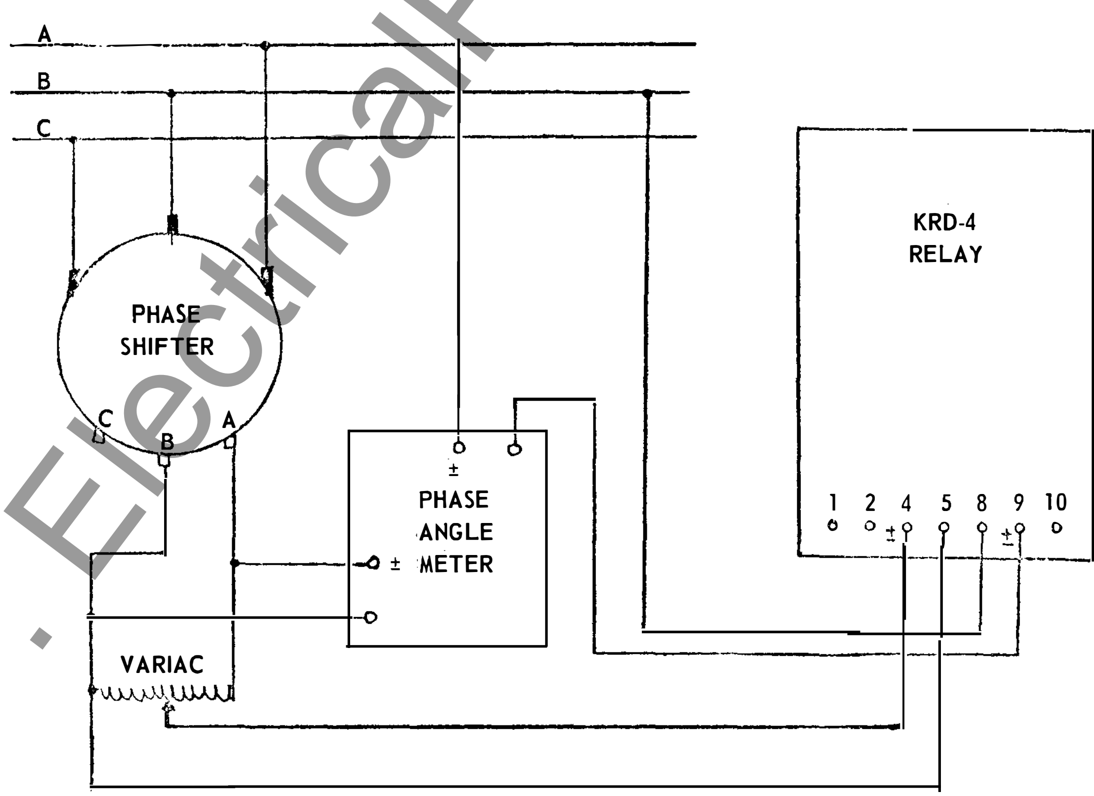
Adjust the contact gap for approximately 5/64" (-1/64", +0).

Close the main relay contacts and check to see that the relays pick up and the target drops between 1 and 1.2 amperes d-c.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, interchangeable parts can be furnished to the customers who are equipped for doing repair work. When ordering parts always give the complete nameplate data.

KRD-4 RELAY
TEST CIRCUIT



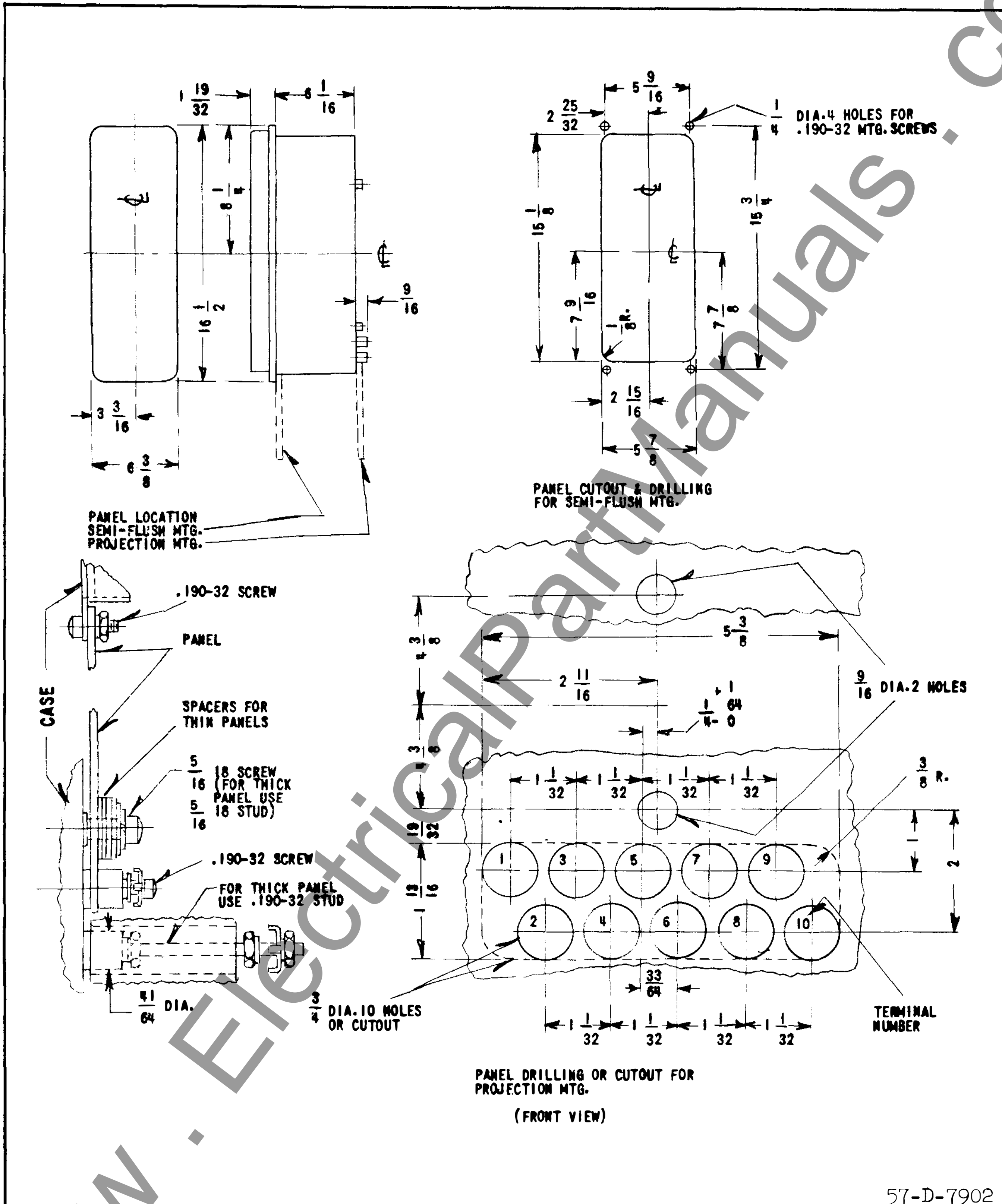


Fig. 7. Outline and Drilling Plan for the Type KRD-4 Relay in the FT31 Case.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE SRGU DUAL POLARIZED GROUND DIRECTIONAL RELAY

APPLICATION

The SRGU is a high speed dual-polarized directional overcurrent ground relay. It may be used as a current or potential polarized relay. It is suitable for overreaching pilot systems where the pilot auxiliary provides a coordinating delay of at least 15 ms during a sudden reversal in the direction of fault-power flow due to a sequentially cleared external fault. This SRGU design is not suitable for underreaching applications, pilot or non-pilot, since the overcurrent unit is not designed for minimum transient overreach and the directional-unit reset during a reversal is as much as 12 ms.

CONSTRUCTION AND OPERATION

As shown in Fig. 1, 2, & 3 the relay contains a power supply, a directional unit and overcurrent unit in a 19 inch rack unit.

Directional Unit

The directional unit consist of air gap current transformers, T_2 and T_3, a voltage transformer T_1, a phase shifting network, and two printed circuit boards (dual directional and directional amplifier).

Transformer T_1 and T_2 are used in the current polarizing circuit and in the operating circuit. The operating current transformer has two separate secondary windings.

The phase shifting network consist of a capacitor (C6), resistor (R1) and a reactor (L1) in voltage polarizing circuit and a reactor (L2) in current polarizing circuit. Fig. 3 shows the connections of the transformers and the phase shifting network to the ring modulator.

The directional circuit board consist of two sets of ring modulators, an amplifier, a timer, a filter and an output transistor.

The ring modulator consists of four diodes. The anode of each diode is connected to the cathode of the following diode to produce a maximum output voltage of 1.4 volts or two diodes forward voltage drop.

Amplifier: The amplifier consist of the two NPN transistors 1Q1, and 1Q3. The second stage of the amplifier is an emitter follower which provides an output to the next stage.

The turn on timer consists of a potentiometer 1R14, a resistor 1R12, a unijunction transistor 2Q1, a capacitor 1C3, and normally conducting transistor 1Q4 for a rapid discharge of the capacitor.

The filter consists of a diode 2D1, a capacitor 2C1 and the resistor 2R3. There are two outputs one of which is the directional unit output. The other controls the overcurrent unit. The directional outputs of a NPN 2Q2 and PNP 2Q3 with a diode 2D2 and zener diode 2Z1 for the protection of output unit from the surge. The control output unit consist of two NPN transistors 2Q4 and 2Q5 in which 2Q5 is normally conducting.

Instantaneous Overcurrent Unit

The overcurrent unit consists of an input transformer T4, a setting circuit, a phase splitter circuit, a sensing circuit, a voltage regulator circuit, a feedback circuit and a transistor output.

1. Input Transformer - A two winding type with a non-tapped primary winding and a tapped secondary winding, the secondary is connected to the setting circuit and from the fixed tap to the phase splitter circuit.

2. Setting Circuit - The setting circuit is connected across the secondary winding of the input transformer and consists of two branches, a resistor and a rheostat, connected in parallel with a resistor and zener diode. This circuit loads the transformer and produces a secondary voltage proportional to the input current. The rheostat has a locking feature to minimize the accidental change of current setting.

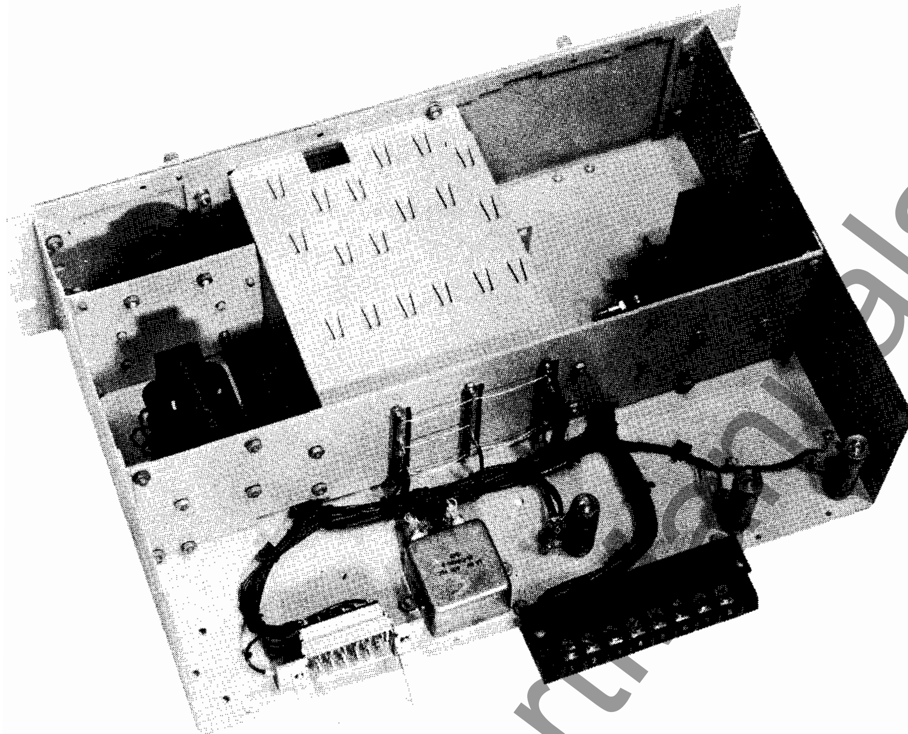


Fig. 1. Relay's Front Picture

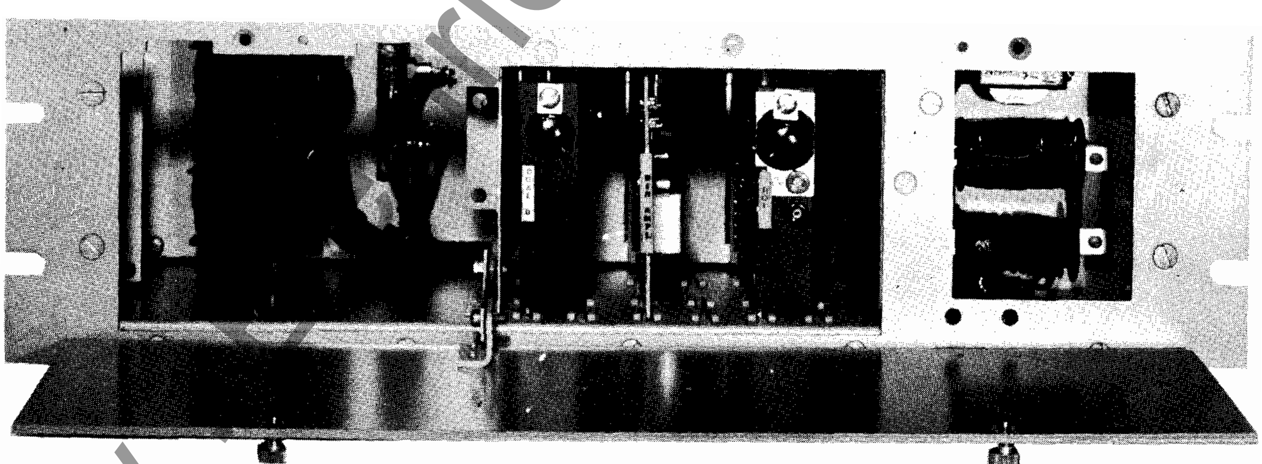


Fig. 2. Relay's Rear Picture

Phase Splitter Circuit

Consists of two capacitors, resistor, potentiometer, and a three-phase rectifier bridge. This circuit converts the single phase ac voltage from the output of the transformer to a three phase voltage and rectifies this voltage to dc.

Sensing Circuit

Consists of three resistors, a transistor and a zener diode. This circuit is connected between the output of the phase splitter circuit and the amplifier circuit. In this circuit, the reference voltage is established which turns the transistor on. To turn the transistor off, the output voltage from the phase splitter must be less than the reference voltage.

Feedback Circuit

Consists of a resistor, potentiometer and diode. This circuit controls the dropout current of the relay.

Voltage Regulator Circuit

Consist of a silicon power regulator and a series resistor. The silicon power regulator is a 10 watt zener diode mounted on an aluminum heat sink. The series resistor is used to reduce the supply voltage to the zener voltage.

Case

Jack plug on the rear has 24 terminals numbered left to right and top to bottom. Thus terminal No. 1 is located in the upper left hand corner when viewed from the rear and terminal 24 is in the lower right hand corner. Terminal No. 1 is connected internally to the chassis ground and may be used for grounding connecting cable shields (when used).

There is also an 8 point terminal block for the current circuits. It is located in the right hand side of the rear when viewed from the back. The terminals are numbered from left to right.

The chassis case, cover, and front panel have electrical connections assured by the use of shakeproof washers which cut through any paint or protecting coating to make electrical contact with the base metal. The complete relay rack is then grounded to the switchboard or cabinet by shakeproof washers.

The front door is connected to the relay case by two hinges and a slotted strap from the bottom, and can be closed by two screws which are located at the top of the door. The slotted straps in the bottom allows the door to be opened up to 90 degrees and stops the door from sliding to the left and right. The door can be removed by unscrewing the slotted strap from the door.

The front panel consists of 2 parts:

1. The circuit boards.
2. Two potentiometers IR14 and 3S1. 1R14 is used for timing adjustment in the directional circuit board, and the 3S1 is used for current setting in the overcurrent unit.

Printed Circuit Board Assembly

The printed circuit board assembly shown in Fig. 9 consists of three separate boards (1) Dual Directional Circuit Board, (2) Directional Amplifier Circuit Board (3) Overcurrent Circuit Board. They contain all the resistors, diodes, transistors and the unijunction necessary to perform the function of a dual polarized directional relay. In Fig. 3 all the components are identified by a number and a letter followed by a number. The first number (a) indicates circuit board number, the letter is used to specify the component type and the second number indicates the component number. In this circuit board, the resistors are identified by "R", the diodes by "D", the zener diodes by "Z", transistors by "Q", capacitors by "C", and the test point by "TP". Box in the transistors indicates normally conducting transistors.

When facing the component side of the printed circuit board, with terminals at the bottom, terminals are numbered 1 to 14 from right to left. These terminal numbers are shown in the internal schematic and will be referred to as printed circuit terminals "TCT", in the trouble shooting section.

Directional Unit Operation

Refer to internal schematic Fig. 3. The operation of the relay is as follows:

The potential circuit of the directional unit is tuned to 60 Hz, but the secondary side of the current transformer has been phase shifted to get a maximum sensitivity of 60 degrees.

Diodes 1D1 to 1D4 constitute a ring modulator or a diode phase comparator, when the two input currents have the same instantaneous polarity 1TP-1 is positive with respect to negative then transistor 1Q1 turns on. If the two input currents are of opposite polarity or if either input is zero the voltage 1TP-1 will be negative or zero with respect to negative and 1Q1 will be off and 1Q4 will be on, to short circuit capacitor 1Q3. The same thing applys to the ring modulator consisting of diodes 5 to 8.

Assume 1TP1 goes positive to turn on 1Q3. Then capacitor 1C3 charges, and if the voltage across the the capacitor reaches the "firing voltage" of the unijunction transistor, the unijunction fires. The current pulse resulting from the unijunction will be transfered to the capacitor 2C1 and hence turns on 2Q2 and 2Q3 and the output voltage appears at varicon terminal 6. Also it turns 2Q5 off to develop the overcurrent unit output.

1R14 is adjusted so that the time required for 1C3 to reach the voltage level of the unijunction is 4.1 m.s. If one or both input quantities goes to zero, and causes transistor 1Q4 turns on, 1C3 is rapidly discharged and the output goes to zero.

Two sets of Ring Modulators are used, one for voltage polarizing and the other for current polarizing. The output of the Ring Modular from the current polarizing circuit is fed back to 1Q3 and if either 1Q1 or 1Q2 or both turn on, 1Q4 will be turned off and the capacitor 1C3 starts to charge up.

The output circuit consists of two transistors, 2Q3 and 2Q5, in which 2Q5 is normally conducting and supervises the overcurrent unit. The normally conducting transistor, of the directional unit, is connected to the input of the first transistor 3Q1 in overcurrent unit, so that short circuits any voltage resulting from the overcurrent unit. If the direction of current is in the trip direction, the directional unit will pick up and the output transistor will act as an open circuit, and allows the overcurrent unit to operate.

The second output of the directional unit consist of two transistors. These two transistors are normally off when the trip signal comes from the unijunction transistor, turns the NPN transistor 2Q2 on, and then allows the PNP transistor 2Q3 to saturate, and hence a twenty volt output will appear across resistor 2R7.

Overcurrent Unit Operation

The overcurrent unit is also a static device and produces a dc voltage output when the input current exceeds the set value.

The components of the overcurrent unit are connected as shown in Fig. 3 with no input to the relay, transistors 3Q1 and 3Q2 are in the nonconducting condition and no output is obtained from the relay. Zener diode 3Z1 of the sensing circuit establishes the reference voltage from the base of 3Q1 to negative and allows a base current to flow in 3Q1 through 3R5 to negative.

When ac current is applied to the primary of the transformer T4, a voltage is produced on the secondary side that is proportional to the amount of resistance in the rheostat 3S1. This single phase voltage is applied to the phase splitter circuit where a three phase voltage is produced, rectified, and applied to resistor 3R5 of the sensing circuit. If the voltage from the rectifier is greater than the reference voltage across the sensing circuit, 3Q1 turns on to allow 3Q2 to turn on which produce a 20 volts dc output.

When 3Q2 turns on, positive feedback voltage is applied to the base of 3Q1. By varying the magnitude of this voltage, the dropout of the relay can be regulated from approximately 98% to 0% of the pick up.

When large current are applied to the primary of the input transformer, the zener clipper on the secondary prevents the current from becoming excessive.

Relay Operation (Directional and Overcurrent)

The type SRGU relay is connected to the protected transmission line as shown in Fig. 4. The relay operates for ground fault currents of a definite magnitude that are flowing in a specified direction with respect to the reference voltage or current.

The directional unit circuitry of the relay compares the phase angle between the fault current and the polarizing quantities of the system and produces either an output voltage for a fault in the trip direction or no output for a fault in the non-trip direction. Relay operation occurs when both the directional unit and the instantaneous overcurrent unit produce a 20 dc voltage output. Hence, the fault current must be greater than the setting of the overcurrent unit.

For a fault in non-trip direction, the transistor 2Q5 of the directional unit short circuits the base to emitter junction of transistor 3Q1 of overcurrent unit, and does not permit the transistor 3Q1 to turn on. For fault current in the trip direction, the directional unit operates and removes this short circuit, allowing the overcurrent unit to produce an output simultaneously with the directional unit output.

CHARACTERISTICS

Directional Unit

1. As a voltage polarized directional unit, "maximum sensitivity" occurs with current lagging voltage by 60° + 6°.

   As a current polarized directional unit, "maximum sensitivity" occurs with operating and polarizing currents in phase ± 6°.

Overcurrent Unit

2. The SRGU relays are available in the following current ranges:

RANGE	SCALE MARKING				
.5-2 AMPS.	.5	.75	1.0	1.5	2.0
1-4 AMPS.	1.0	1.5	2.0	3.0	4.0
2-8 AMPS.	2	3	4	6	8

The setting is the minimum current required to obtain a 20 volts dc output. For pick up settings between calibrated markings refer to the section under "Setting". The SRGU relay is designed for dual polarizing and can be polarized from a zero sequence potential source, a zero sequence current source or from both simultaneously.

Time Curves:

The time curves for SRGU relay are shown in Fig. 5, 6, and 7. Figure 5 includes directional unit operating time for current, voltage or dual polarized.

Fig. 6 is overcurrent unit operating time, and Fig. 7 is overcurrent unit reset time.

Operating Time:

The tuned circuits in the directional unit impart a slight inverse time characteristic at low energy levels and cause a longer operating time at the minimum pick up.

Reset Time:

The tuned circuits in the directional unit also delays the reset time, and the amount of delay depends on the initial energization (the max. reset time is 30 ms).

Current Reversal Reset Time:

When a fault current reversal occurs, the relay is reversed and the directional unit resets in 12 ms or less.

Both the directional unit and overcurrent unit must operate before a trip output can be obtained. Hence, the unit which takes the longer time to operate determines when an output will occur. The overcurrent unit cannot operate until the short circuit in its input circuit is removed by the operation of the directional unit. Once the directional unit operates, the overcurrent unit will operate instantaneously.

If the operating and polarizing quantities are more than the minimum required the directional unit operates, but because of the setting, the overcurrent unit may not operate and therefore the overall output will be zero.

If under these conditions, a current reversal happens, the directional unit resets a maximum of 12 ms to short circuit the overcurrent unit, but the overcurrent unit may operate in less than 12 ms, and hence an illegitimate 20 volts output will appear across the varicon terminals 5 and 3.

Reset Time:

Although the reset (de-energization) of the directional unit is longer than overcurrent unit. The relay reset time is completely independent of directional unit reset time, and it only depends on overcurrent unit reset time. Therefore, the curve shown for overcurrent unit reset time is the same for the relay reset time.

Setting (Overcurrent Unit)

The operating level of the relay is selected by adjusting the rheostat 3S1 in the front of the panel. Settings in between the scale marking can be made by applying the desired current and adjusting the rheostat until an output is obtained.

Directional Unit

No setting is required.

ADJUSTMENT AND MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory.

Upon receipt of the relay, no adjustments, other than those covered under "Settings" should be required.

Acceptance Check

The following check is recommended to insure that the relay is in proper working order.

Overcurrent Unit

A. Minimum trip current

1. Apply the rated dc to terminals 3 and 4 (4 is positive) and make sure 20 ± 2 volts exist at the "printed circuit board" terminal 1 and 14 (14 is positive). For checking the pick up remove the directional amplifier board, and then by the circulating the specified current through "Terminal Block" terminals 1 and 2 the dc voltmeter in the output should read approximately 20 volts, when the current is within 3% of the setting.

2. Dropout;

   After checking pick up, the dropout should be checked to be approximately 97% of the pick up with the ac current gradually reduced.

Directional Unit

Refer to Fig. 8 with the directional amplifier back in place. Apply 100 volts, 60 Hz to terminals 7 and 8. The output voltage measured from jack terminal 2JR to negative should be zero.

Remove 60 Hz voltage input from terminals 7 and 8 and circulate 10 amperes 60 Hz through "Terminal Block" terminals 1 and 2. The output voltage measured from 2JR to 2JB should be zero.

Apply 100 volts 60 Hz to terminal 7 and 8 circulate 18 amperes through "Terminal Block" terminals 1 and 2 with polarities as shown on the external schematic.

Adjust the phase angle between voltage and current until voltage output of 20 volts ± 10% from jack terminals 2JB and 2JR is obtained. At this point the angle between voltage and current should be 330° ± 3° voltage leading current. Adjust the phase shifter until the 20 volts output drops to zero. This angle should be 150 ± 3 degrees.

Circulate 5 amperes into "Terminal Block" terminal 4 and out 3 into terminal 1 and out 2, (in phase). The voltage output should be obtained.

Apply 10 amperes into 4 out 3, into 1 out 2. Apply 100 volts to terminals 7 and 8, (current lags voltage by 60°). Voltage output should be obtained. Reverse terminal connections 7 and 8, the output should read zero. Take out terminal 7 and 8, the relay should operate.

Repair Calibration

If the relay does not meet the acceptance tests or has been dismantled for repairs, use the following procedure to put in proper working order.

Avoid stressing component leads. If a test probe must be connected to a component lead, connect it so as to avoid stress on the leads of delicate components. Use the test points provided wherever possible rather than connecting a test probe directly to the component board.

Use the following procedure for calibrating the SRGU Relay if the relay adjustments have been disturbed. This procedure should not be used until it is apparent that the relay is not in proper working order.

A. Directional Unit (Polarity Check)

1. Connect as per Fig. 8.
2. Replace the dual directional circuit board with a card extender style 849A534G01 and disconnect, not remove, all other boards.

   Apply rated dc voltage across "Varicon" terminal 3 and 4, with terminal 4 positive. Measure the voltage across the printed circuit board terminal 1 and 14 with positive on terminal 14. The voltage should be 20 ± 2 volts.

3. Connect the dual directional board and all the other boards back to the relay.
4. Circulate 10 amperes through "Terminal Block" terminals 1 and 2.
5. Apply 100 volts to Varicon terminal 7 and 8, (7 is polarity) and circulate 10 amperes through "Terminal Block" terminals 1 and 2, (1 is polarity). Set the phase shifter to 60° (current lags voltage). The relay should operate.

6. Circulate 5 amperes into "Terminal Block" 4 out of 3, into 1 and out 2. Disconnect the voltage from terminals 7 and 8. The relay should operate.

7. If the relay operated in 5, but not in 6, the connections to "Terminal Block" terminals 3 and 4 are wrong and should be reversed.

8. If relay operated in 6 but not in 5, the connections to 7 and 8 are reversed and should be changed.

9. If the relay did not operate in 5 or 6, the connections to "Terminal Block" terminals 1 and 2 are wrong and should be changed.

Phase Angle Adjustment: Fig. 8.

10. Turn the phase shifter in either direction until the dc voltage output between terminal 2JB and 2JR in the front panel just drops to zero, and read the phase shifter angle. (angle between I and V).

11. Continue the turning in the same direction until the dc voltmeter across ack terminal 2JB and 2JR just reads 20 ± 2 volts, and read the angle on the phase shifter.

12. Adjust the potentiometer 1R14 in front panel until the difference between the above angles becomes 180 ± 2 degrees.

Zero Sensitivity Check:

13. Apply 120 volts and 10 amperes as indicated above.

14. Check that the zero sensitivity angle occurs within 4 degrees at 150° and 330° of the phase shifter.

Minimum Pick Up Check: Fig. 8.

15. Apply 1 volt between terminals 7 and 8 (7 is polarity) and circulate 0.4 amperes through "Terminal Block" terminals 1 and 2 (1 is polarity). The relay should pick up at maximum sensitivity (current lags 60°).

16. Disconnect the voltage terminal (7 and 8) and circulate 0.5 amperes through "Terminal Block" terminals 1 and 2 and through 4 and 3. The relay should operate at 20 volts dc which is obtained between "Jack Terminal" 2JR and 2JB. Also check a 20 volts dc output between "printed circuit board" terminals 6 and 1 (6 is positive).

B. Overcurrent Unit Adjustment

Phase Splitter Adjustment

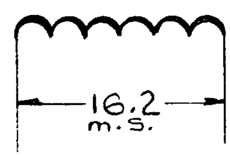
1. Disconnect the directional amplifier circuit board from the relay.

2. Extend module with board extender, and adjust knob on rheostat 3S1 (front of module) such that white pointer is equidistance from each side of locking tab when S1 is fully rotated.

3. Turn rheostat 3S1 all the way towards lowest dial current marking.

4. Circulate minimum current marked on the dial through terminals 1 and 2.

5. Connect scope across 3TP-2 and printed circuit terminal #1 (ground). Adjust potentiometer 3R13 (middle-top of board) to obtain following waveform:



Dial Calibration

1. Apply rated dc voltage to relay.

2. Connect high resistance dc voltmeter to test points on front of module. (Red J = Pos. Black J = Neg.).

3. Apply desired 3S1 current to "Terminal Block" 1 and 2.

4. Turn 3S1 rheostat until the relay operates as indicated by a sudden reading of approximately 20 volts dc on meter.

Dropout Adjustment (3R12)

1. Set Rheostat 3S1 on minimum dial current value, apply rated dc voltage, and connect the dc voltmeter across "Jack Terminal J_R and J_B" of overcurrent unit.

2. Apply minimum setting current to proper relay terminals. Overcurrent unit should operate at a current level within 2% of the marked value on the dial.

3. Reduce ac current to 97% of pick up current for minimum setting.

4. Rotate potentiometer 3R12, until the relay resets as indicated by voltmeter dropping from 20 to zero volts.

5. Verify pick up and dropout by raising and lowering ac current. The overcurrent unit should pick up within 2% of marked value and dropout at 97% of pick up current.

Trouble Shooting Procedure

Use the following procedure to locate the source of trouble if the relay is not operating correctly.

1. The first step is inspecting all wires and connections of the transformers, and also paying particular attention to printed circuit board terminal.

2. Check phase shifting component on their connection and values as listed on the internal schematic of the relays.

3. Check the circuit board at different test point as listed below by an oscilloscope to see if the waveforms of Fig. 10 are obtained for a given test condition.

Test Condition:

Set the relay for voltage polarizing, apply 100 volt to the voltage terminal and 10 amperes to the operating current transformer (terminal block 1 and 2) with the proper polarity. Set the phase shifter on "0", check the test point number 1 by an oscilloscope and compare them with the given waveforms.

If the ring modulator output is obtained but there is no final output, the trouble would be on the circuit board.

If the final output is obtained, and the period of the waveforms are not the same as shown for this particular angle relation between current and voltage, the phase shifting network of the relay has to be checked.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, interchangeable parts can be furnished to the customers who are equipped for doing repair work. When ordering parts always give the complete nameplate data.

BURDEN DATA

DIRECTIONAL UNIT VOLTAGE CIRCUIT

$I_O = 0$ or $I_O = S14$

VOLTAGE	VA	WATT	VAR
100	9.20	8.9	2.3
75	5.10	4.92	1.27
50	2.24	2.16	0.62
25	.56	.54	.015
10	.08	.078	.022
5	.015	.0144	.0041
1	.006	.0058	.0016

DIRECTIONAL UNIT, CURRENT CIRCUIT

OPERATING CURRENT	VA	WATT	VI
1	.043	.041	.0125
5	1.05	1.0	.031
10	4.2	4.0	1.23
20	18.0	17.2	5.25
30	39	37	12.7
40	64	61.	20.8
50	120	115	35

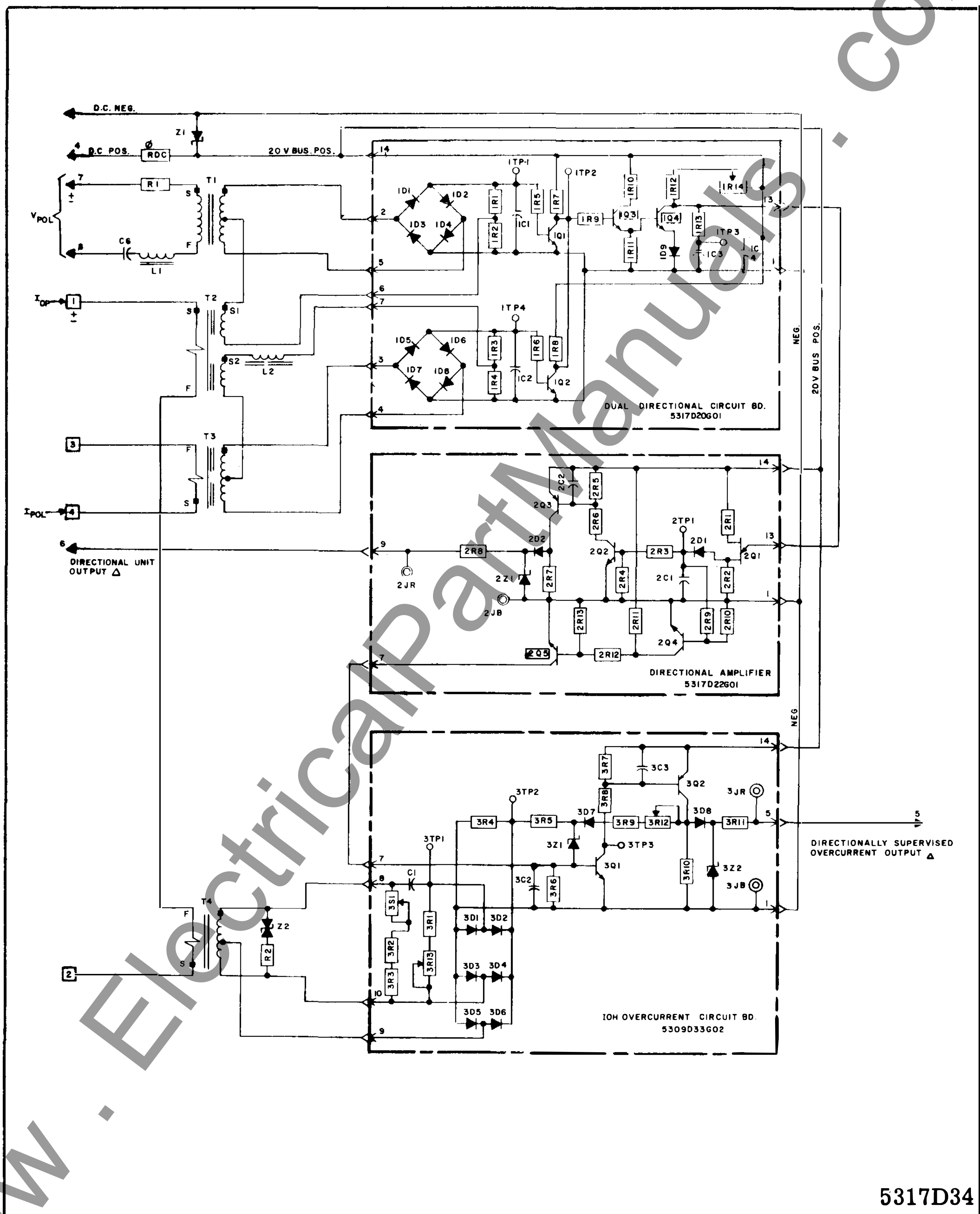


Fig. 3. Internal Schematic

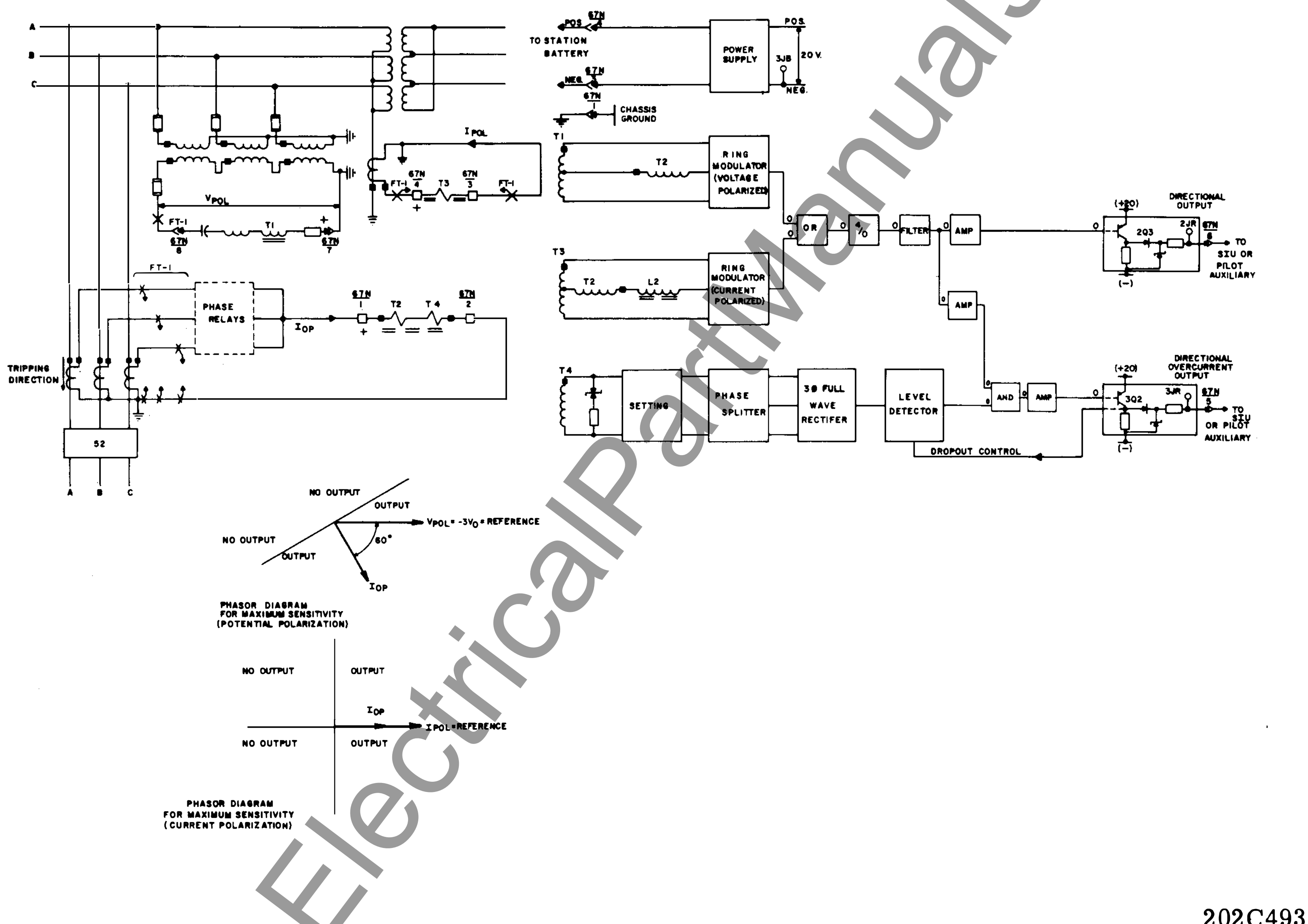


Fig. 4. External Schematic

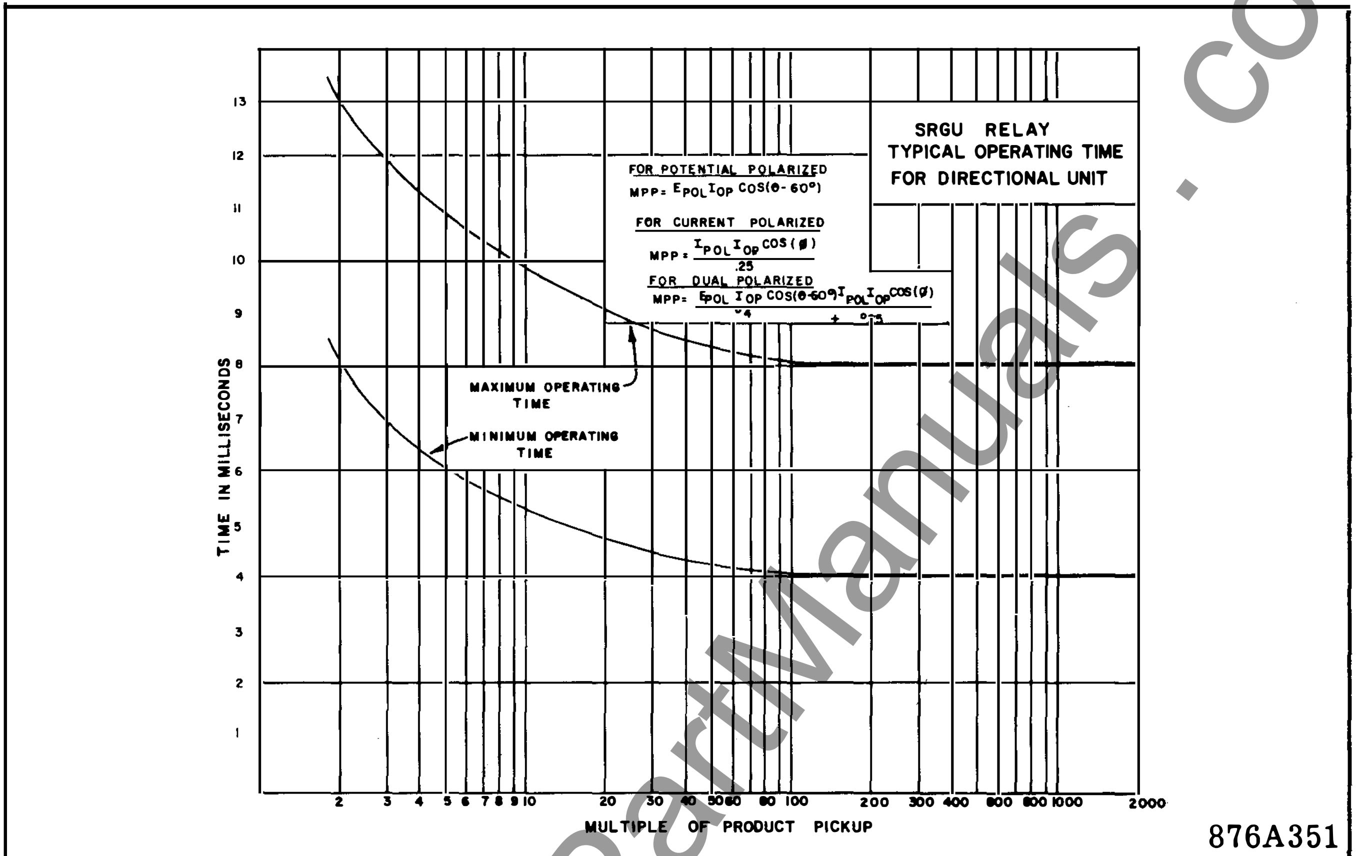


Fig. 5. Operating Timing Curve For Directional Unit.

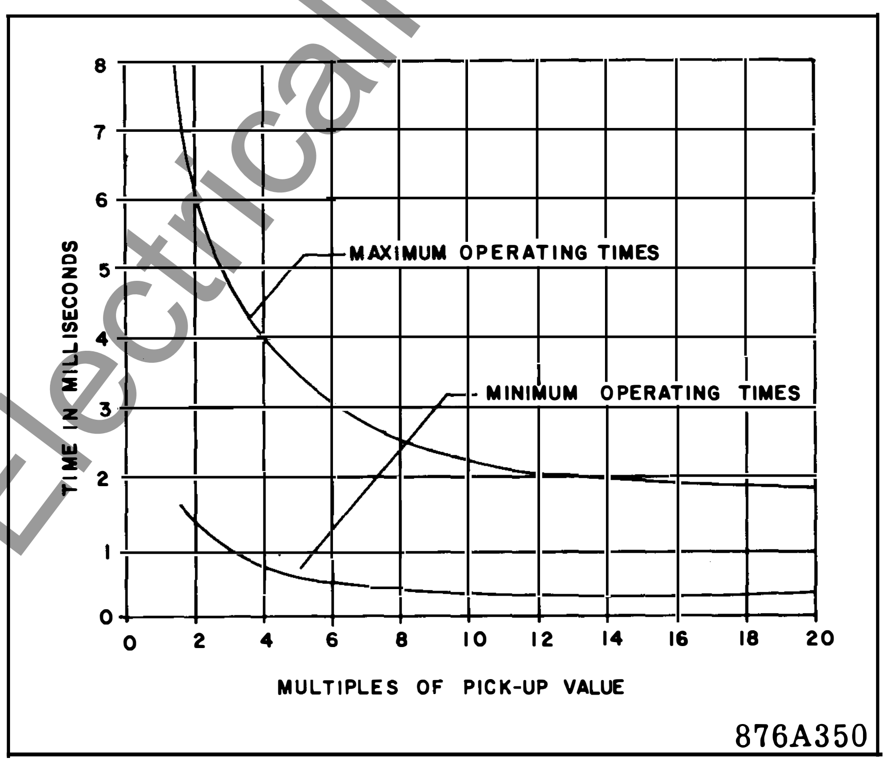


Fig. 6. Operating Timing Curve For Overcurrent Unit.

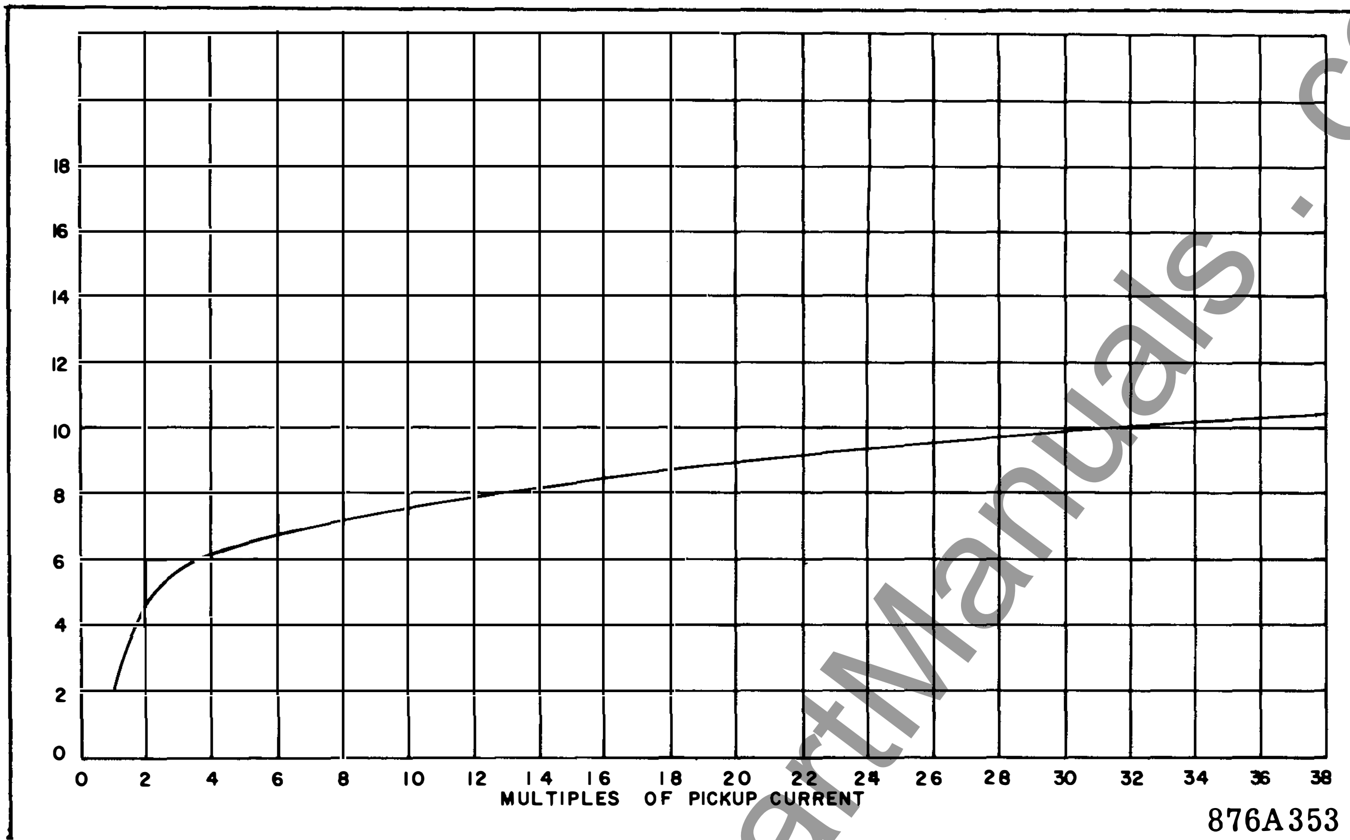


Fig. 7. Reset Timing Curve For Overcurrent Unit.

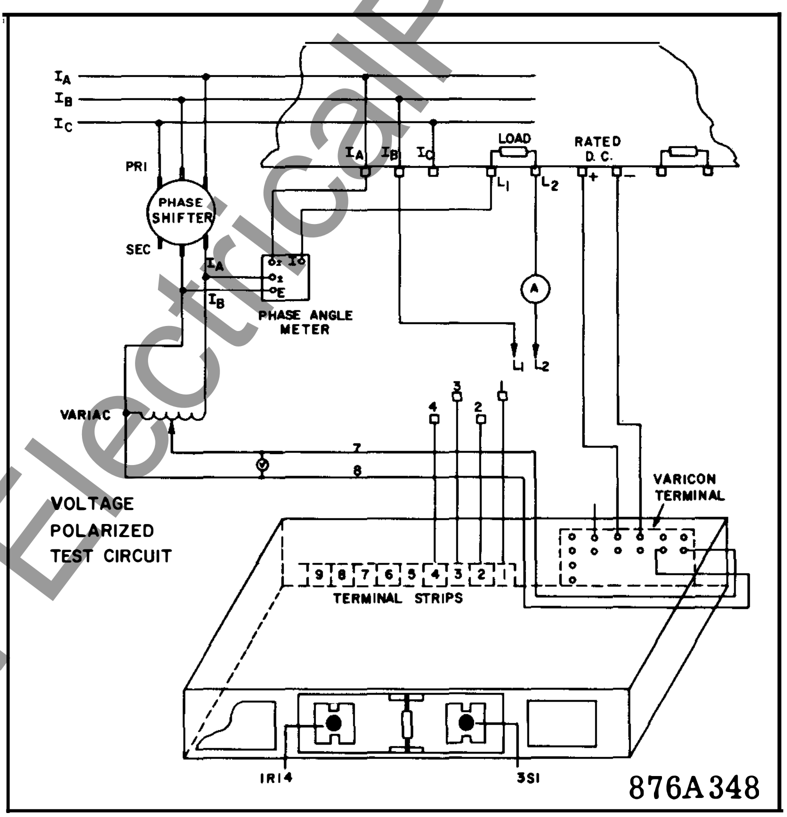
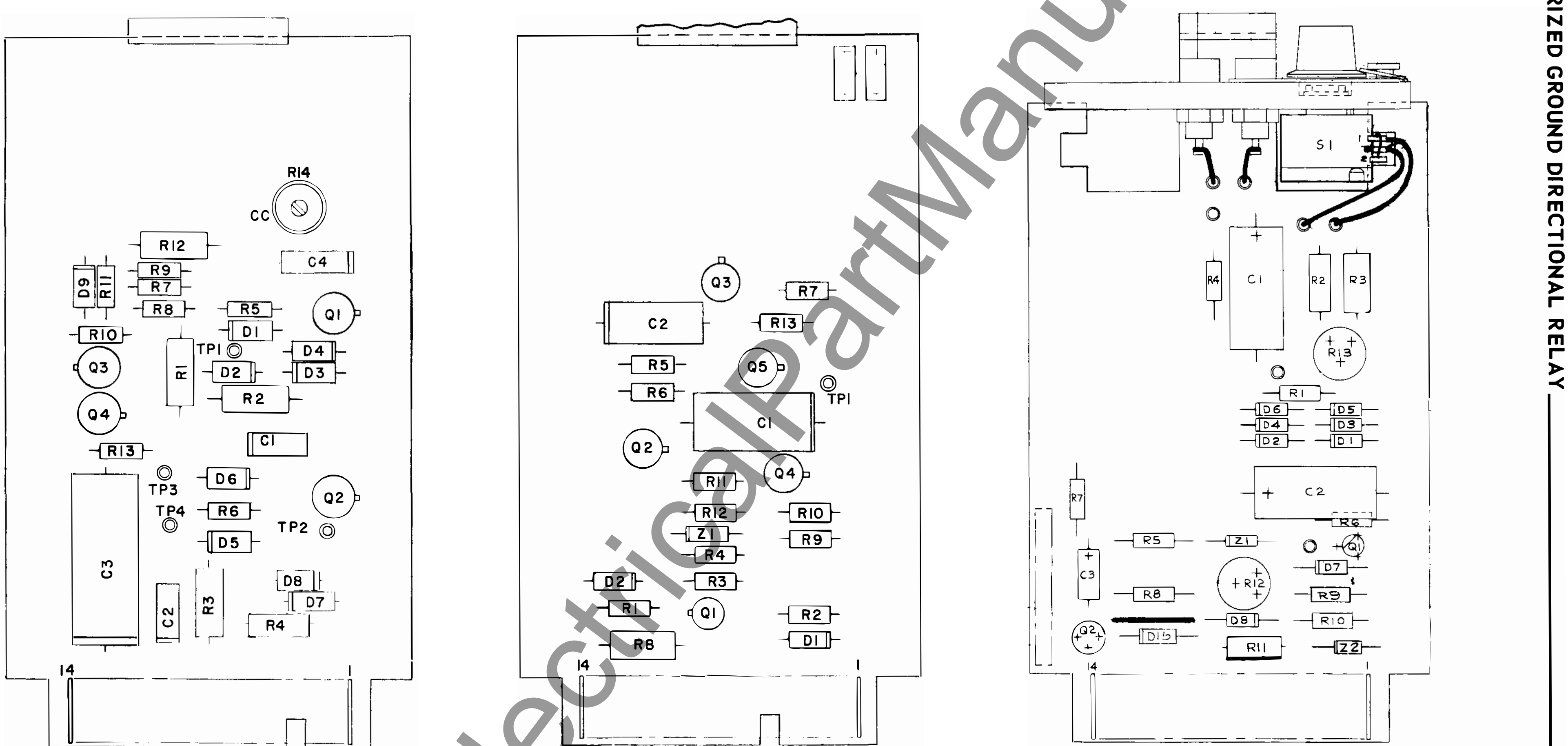


Fig. 8. Testing Circuit



5317D20
5317D22-5309D33

Fig. 9. Printed Circuit Board

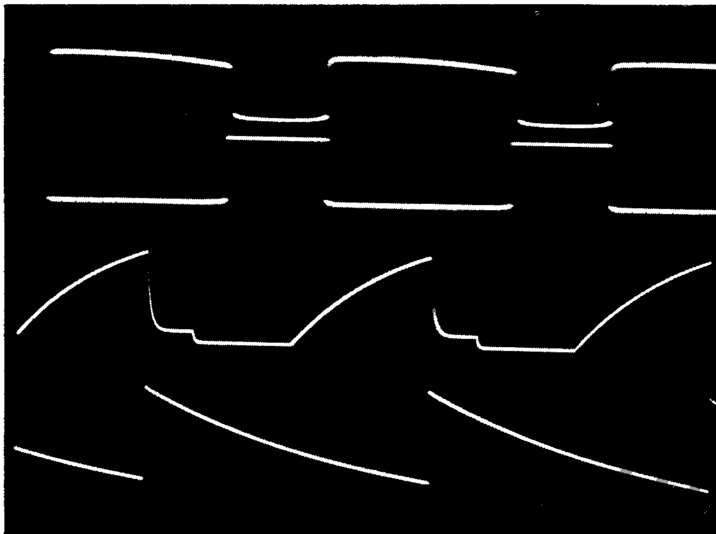


Fig. 10. Waveforms
Sweep — 2 ms/cm.

Voltage #1	*Ring Modulator Output*	*2 volt/cm.*
#2	*Transistor Output*	*10 volt/cm.*
#3	*C1 Output*	*10 volt/cm.*
#4	*Filter Output*	*2 volt/cm.*

WESTINGHOUSE ELECTRIC CORPORATION

RELAY-INSTRUMENT DIVISION NEWARK, N. J.

Printed in U.S.A.

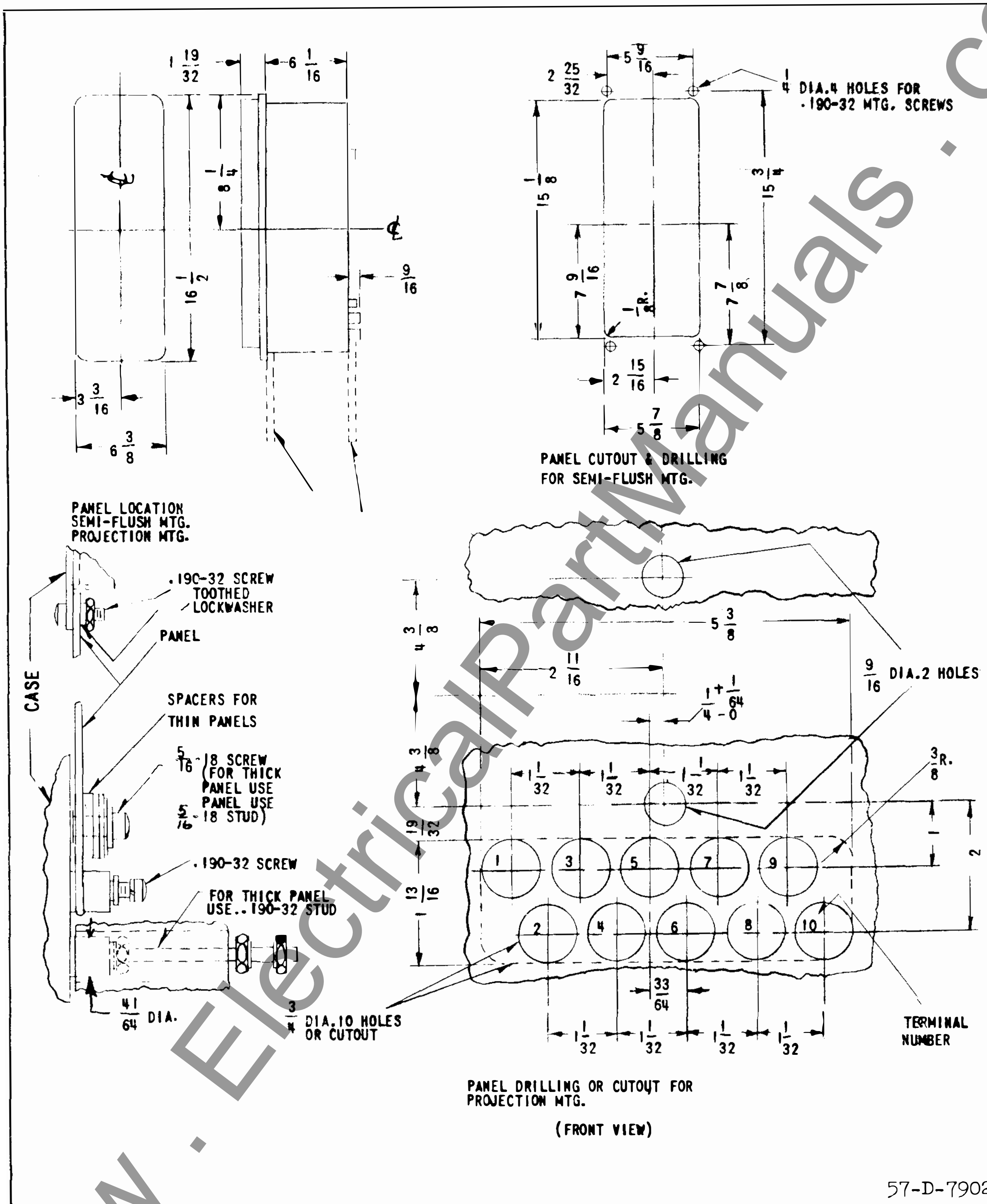


Fig. 11 Outline and Drilling Plan for the KRP, KRC, and KRD Relays in the FT31 Case.

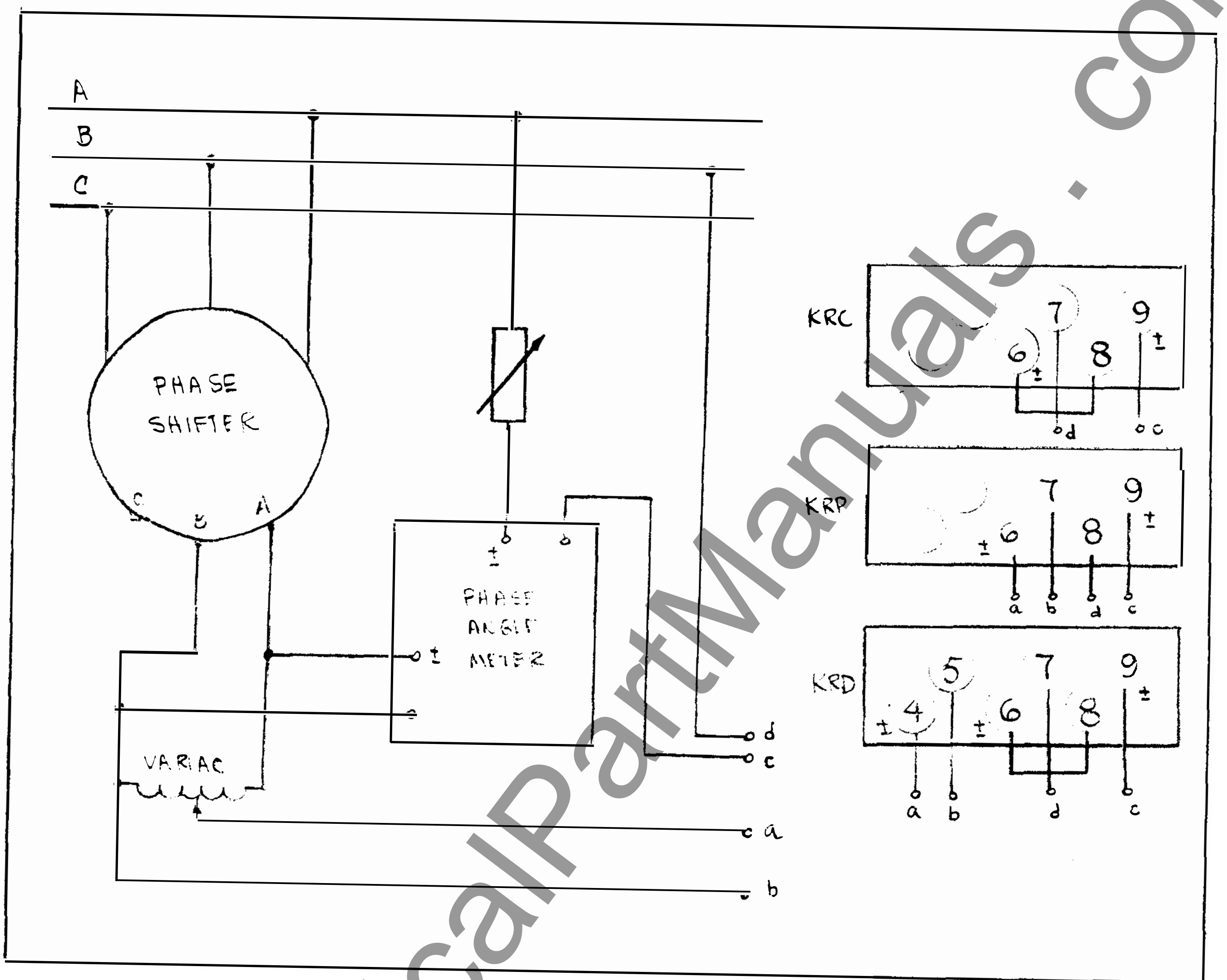


Figure 10. Test Connections

TABLE I

DIRECTIONAL UNIT SENSITIVITY

RELAY TYPE	AMPERE RATING	VALUES FOR MIN. PICKUP τ		PHASE ANGLE RELATIONSHIP
		VOLTS	AMPERES	
KRP KRD (Voltage Unit)	.5-2 1-4 2-8	1	2.0	I lagging V by 60° ττ
		1	4.0	I in-phase with V
	4-16	1	4.0	I lagging V by 60° ττ
	10-40	1	8.0	I in-phase with V
KRC KRD (Current Unit)	.5-2		0.5	I_o leading I_p by 40° ττ
	1-4 2-8		0.57	In-phase
	4-16		1.0	I_o leading I_p by 40° ττ
	10-40		1.4	In-phase

τ The energization quantities are input quantities at the relay terminals.
ττ Maximum torque angle.

TABLE II

DIRECTIONAL UNIT CALIBRATION

RELAY RATING	CURRENT AMPERES	BOTH PLUGS IN CONDITION	ADJUSTMENT
All Ranges	80	Spurious Torque In Contact Closing Direction (Left Front View)	Right (Front-View) Plug Screwed Out Until Spurious Torque is Reversed.
All Ranges	80	Spurious Torque In Contact Opening Direction (Right Front View) (Contacts remain open)	Left (Front View) Plug Screwed Out Until Spurious Torque is in Contact Closing Direction. Then the plug is screwed in Until Spurious Torque is Reversed.

Short circuit the voltage polarizing circuit and open circuit the current polarizing circuit at the relay terminals before making the above adjustments.

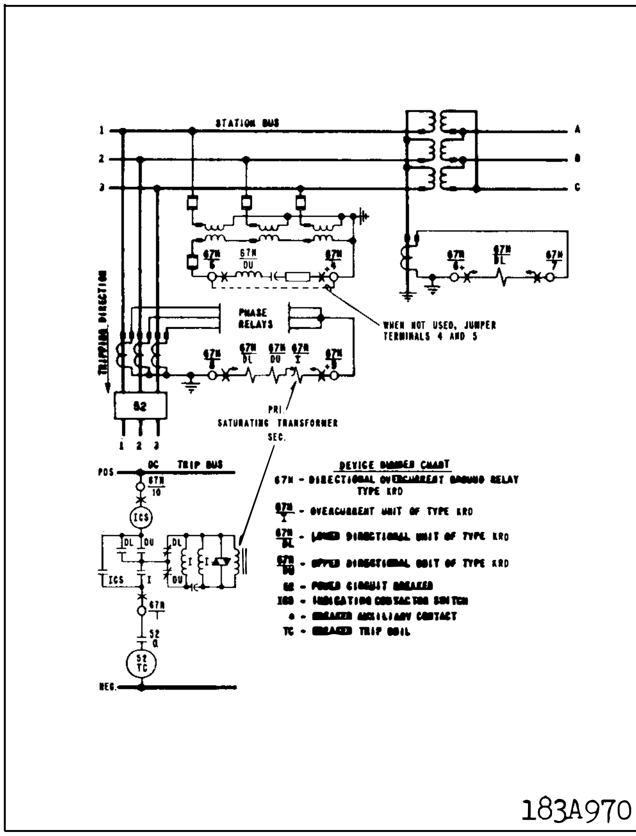


Fig. 9. External Schematic of the Type KRD Relay.

may be desired on some installations in order to insure that the relay will always trip the breaker on zero potential.

Indicating Contactor Switch (ICS)

Adjust the contact gap for approximately 5/64" (-1/64", +0).

Close the main relay contacts and check to see that the relay picks up and the target drops between 1 and 1.2 amperes d-c.

To increase the pickup current remove the molded cover and bend the springs out or away from the cover. To decrease the pickup current bend the springs in toward the cover.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, interchangeable parts can be furnished to the customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data.

RATING OF OVERCURRENT UNIT

RANGE	CONTINUOUS RATING AMPERES	ONE SECOND RATING AMPERES
.5-2	5	100
1-4	8	140
2-8	8	140
4-16	10	200
10-40	10	200

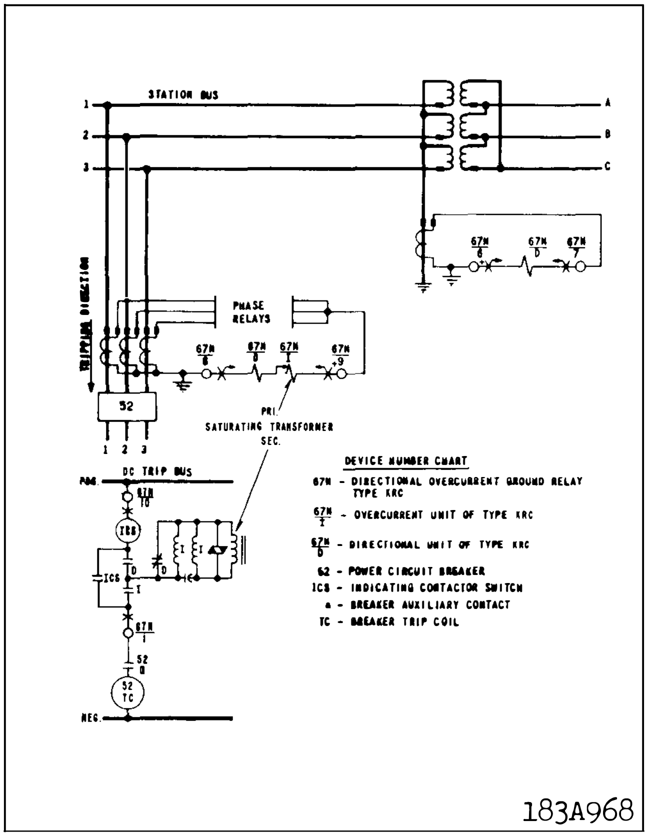


Fig. 7. External Schematic of the Type KRC Relay.

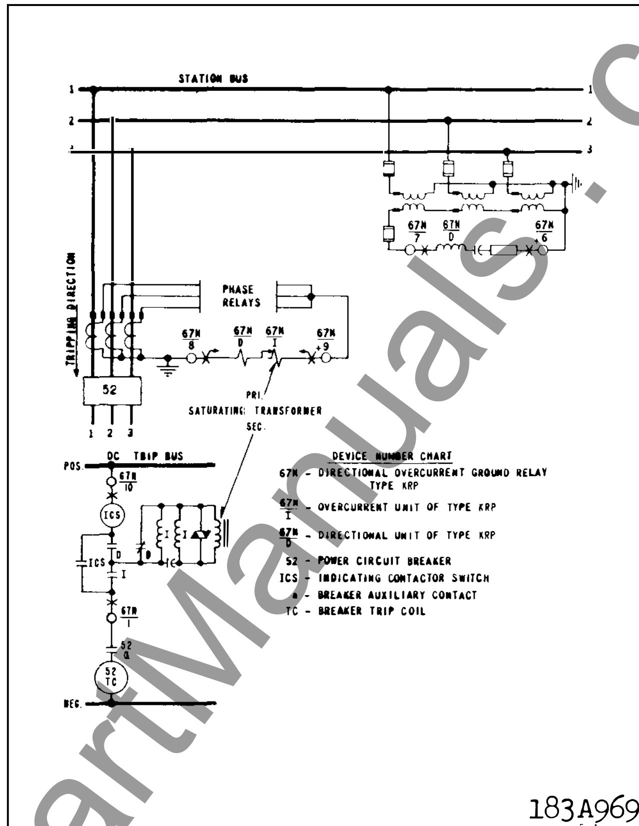


Fig. 8. External Schematic of the Type KRP Relay.

off the stationary contact 3/4 of one turn for a contact gap of .020" to .024". The clamp holding the stationary contact housing need not be loosened for the adjustment since the clamp utilizes a spring-type action in holding the stationary contact in position.

3. Insert tap screw of overcurrent unit in highest tap. The sensitivity adjustment is made by varying the tension of the spiral spring attached to the moving element assembly. The spring is adjusted by placing a screwdriver or similar tool into one of the notches located on the periphery of the spring adjuster and rotating it. The spring adjuster is located on the underside of the bridge and is held in place by a spring type clamp that does not have to be loosened prior to making the necessary adjustments.

The spring is to be adjusted such that the contacts will close as indicated by a neon lamp in the contact circuit when energized with the required current and voltage as shown in Table 1. This table indicates that the spring can be adjusted when the phase angle relationship between the operating circuit and the polarizing circuit is at the maximum torque angle or when the circuit relationship has the operating and polarizing circuits in phase.

4. The magnetic plugs are used to reverse any unwanted spurious torques that may be present when the relay is energized on current alone.

The reversing of the spurious torques is accomplished by using the adjusting plugs in the following manner:

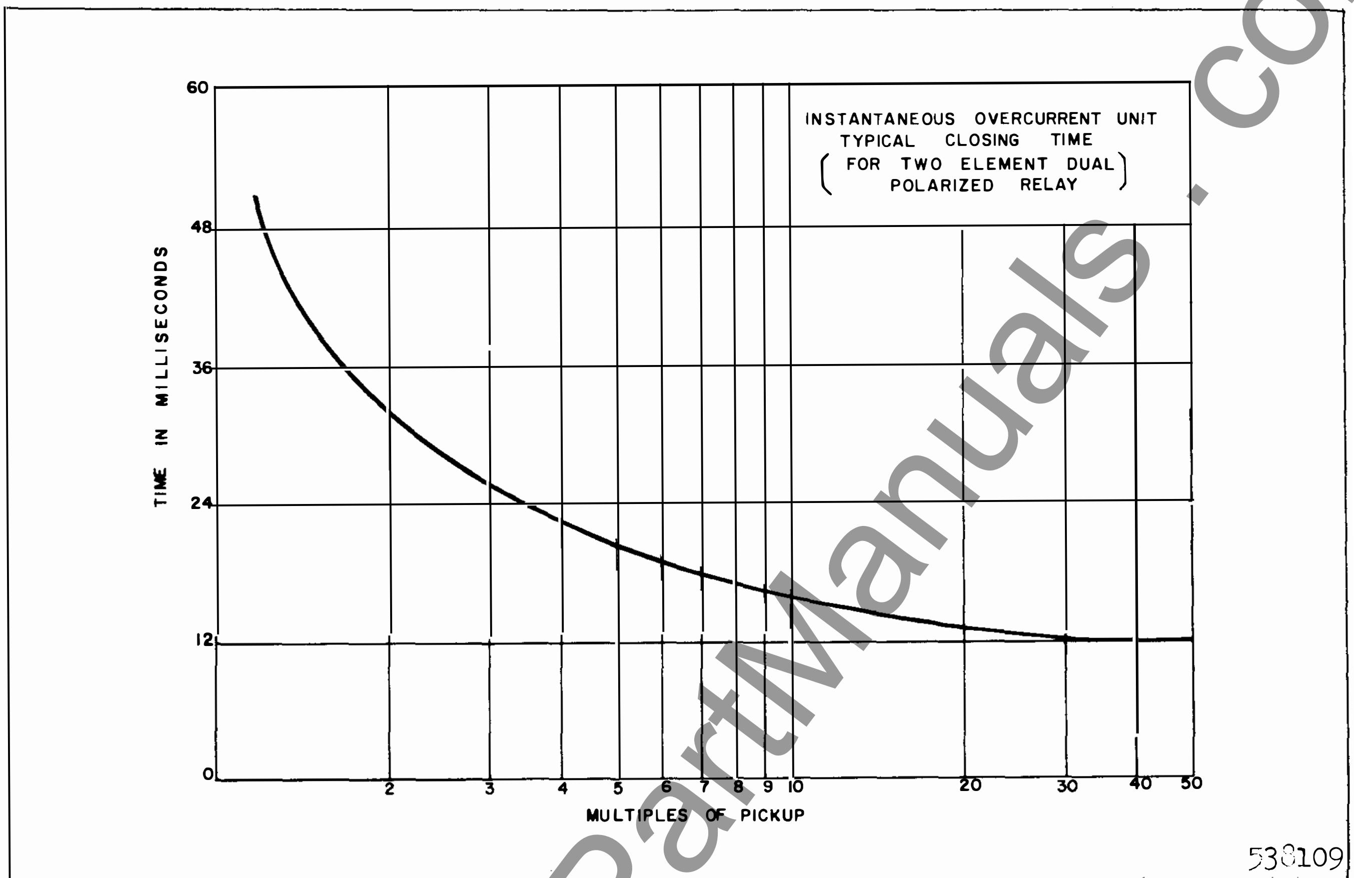
a) Voltage circuit terminals on the voltage polarized relays (KRP and KRD voltage polarized unit) are short-circuited.

b) The polarizing circuit of the current polarized relays (KRC and KRD current polarized unit) are open-circuited.

Upon completion of either "a" or "b", current is applied to the operating circuit terminals as per Table 2.

Plug adjustment is then made per Table II such that the spurious torques are reversed. The plugs are held in position by upper and lower plug clips. These clips need not be disturbed in any manner when making the necessary adjustment.

The magnetic plug adjustment may be utilized to positively close the contacts on current alone. This



* *Fig. 6. Typical Operating Times for the instantaneous Type KRC and KRD overcurrent unit (When Current Polarized) Relays.*

3. The sensitivity adjustment is made by varying the tension of the spiral spring attached to the moving element assembly. The spring is adjusted by placing a screwdriver or similar tool into one of the notches located on the periphery of the spring adjuster and rotating it. The spring adjuster is located on the underside of the bridge and is held in place by a spring type clamp that does not have to be loosened prior to making the necessary adjustments.

Before applying current, block open the normally-closed contact of the directional unit. Insert the tap screw in the minimum value tap setting and adjust the spring such that the contacts will close as indicated by a neon lamp in the contact circuit when energized with the required current. The pick up of the overcurrent unit with the tap screw in any other tap should be within ±5% of tap value.

If adjustment of pick-up current in between tap settings is desired insert the tap screw in the next lowest tap setting and adjust the spring as described. It should be noted that this adjustment results in a slightly different time characteristic curve and burden.

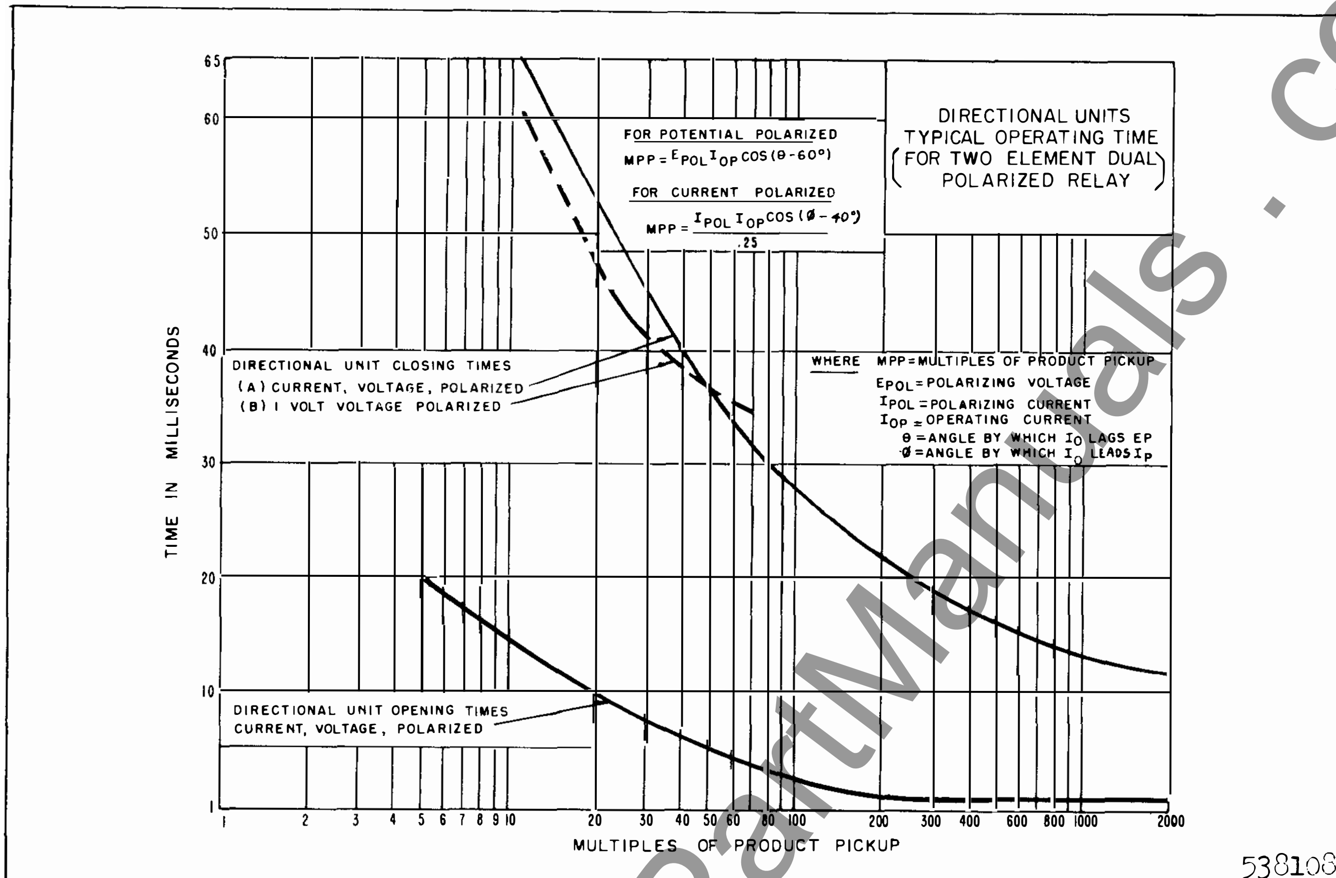
Directional Unit (D)

In the type KRP and KRC relays the directional unit is the lower unit. In the type KRD the directional units are the lower and middle units.

1. The upper bearing screw should be screwed down until there is approximately .025 clearance between it and the top of the shaft bearing. The upper pin bearing should then be securely locked in position with the lock nut.

2. Contact gap adjustment for the directional unit is made with the moving contact in the reset position, i.e., against the right side of the bridge. Advance the right hand stationary contact until the contacts just close. Then advance the stationary contact an additional one-half turn.

Now move in the left-hand stationary contact until it just touches the moving contact. Then back



★ *Fig. 5. Typical Operating Times for the D-Unit of the Type KRP and KRC, KRD Relays.*

tween the bridging moving contact and the adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously.

ROUTINE MAINTENANCE

All relays should be inspected periodically and the operation should be checked at least once every year or at such other time intervals as may be dictated by experience to be suitable to the particular application.

All contacts should be periodically cleaned. A contact burnisher S#182A836H01 is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact.

Calibration

Use the following procedure for calibrating the relay if the relay has been taken apart for repairs or the adjustments have been disturbed. This procedure should not be used unless it is apparent that the relay is not in proper working order. (See "Acceptance Check").

Overcurrent Unit (I)

1. The upper pin bearing should be screwed down until there is approximately .025 clearance between it and the top of shaft bearing. The upper pin bearing should then be securely locked in position with the lock nut. The lower bearing position is fixed and cannot be adjusted.

2. The contact gap adjustment for the overcurrent unit is made with the moving contact in the reset position, i.e., against the right side of the bridge. Advance the stationary contact until the contacts just close. Then back off the stationary contact 2/3 of one turn for a gap of approximately .020". The clamp holding the stationary contact housing need not be loosened for the adjustment since the clamp utilizes a spring-type action in holding the stationary contact in position.

ENERGY REQUIREMENTS – 60 CYCLES

DIRECTIONAL UNIT POLARIZING CIRCUIT BURDEN

RELAY TYPE	RATING	VOLT AMPERES △	POWER FACTOR ANGLE ¢
KRC	230 τ Amperes	1.45	8° Lag
KRP	208 ττ Volts	11.2	28° Lead
KRD Current Unit	230 τ Amperes	1.45	8° Lag
KRD Voltage Unit	208 ττ Volts	11.2	28° Lead

¢ Degrees current leads or lags voltage at 120 volts on voltage polarized units and 5 amperes on current polarized units.

△ Burden of voltage polarized units taken at 120 volts. Burden of current polarized units taken at 5 amperes.

τ One second rating

ττ 30 second rating. The 10 second rating is 345 volts. The continuous rating is 120 volts.

Either of the studs or the mounting screws may be utilized for grounding the relay. The electrical connections may be made directly to the terminals by means of screws for steel panel mounting or to terminal studs furnished with the relay for thick panel mounting. The terminal studs may be easily removed or inserted by locking two nuts on the studs and then turning the proper nut with a wrench.
For detailed information, refer to I.L. 41-076.

The external a-c connections of the directional overcurrent relays are shown in Figs. 7, 8 and 9. If no voltage polarizing source is to be connected to the KRD relay, short-circuit the voltage polarizing circuit at the terminals of the relay.

ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory. Upon receipt of the relay, no customer adjustments, other than those covered under "SETTINGS", should be required.

Acceptance Check

The following check is recommended to insure that the relay is in proper working order;

Overcurrent Unit (I)

1. Contact Gap – The gap between the stationary and moving contacts with the relay in the de-energized position should be approximately .020".

2. Minimum Trip Current – The normally-closed contact of the directional unit should be blocked open when checking the pick-up of the overcurrent unit.

The pick-up of the overcurrent unit can be checked by inserting the tap screw in the desired tap hole and applying rated tap value current. The contact should close within ±5% of tap value current.

Directional Unit (D)

1. Contact Gap – The gap between the stationary contact and moving contact with the relay in the de-energized position should be approximately .020".

2. Sensitivity – The respective directional units should trip with value of energization and phase angle relationships as indicated in Table 1.

3. Spurious Torque Adjustments – There should be no spurious closing torques when the operating circuits are energized per Table 2 with the polarizing circuits short-circuited for the voltage polarized units and open-circuited for the current polarized units.

Indicating Contactor Switch (ICS)

Close the main relay contacts and pass sufficient d-c current through the trip circuit to close the contacts of the ICS. This value of current should be between 1 and 1.2 amperes. The indicator target should drop freely.

The contact gap should be approximately 5/64" be-

ENERGY REQUIREMENTS – 60 CYCLES

TYPE KRD RELAY

AMPERE RANGE	TAP	VA AT TAP VALUE π	P.F. ANGLE ¢	VA AT 5 AMPS. π	P.F. ANGLE ¢
.5-2	.5	0.42	39.5°	28.30	47.0°
	.75	0.51	39.5	19.80	43.0
	1.0	0.63	39.5	14.50	41.0
	1.25	0.78	40.0	12.10	40.0
	1.5	0.97	40.0	10.60	40.0
	2.0	1.44	40.0	8.80	40.0
1-4	1.0	0.65	39.0°	15.20	40.0°
	1.5	1.01	39.5	11.00	40.0
	2.0	1.48	40.0	9.10	40.0
	2.5	2.10	40.5	8.25	40.5
	3.0	3.85	41.0	7.75	41.0
	4.0	4.56	41.5	7.25	41.5
2-8	2	2.01	46.0°	12.75	45.5°
	3	3.44	44.0	9.50	43.5
	4	5.36	42.5	8.40	42.5
	5	7.75	42.0	7.75	42.0
	6	10.71	42.0	7.45	42.0
	8	18.40	42.0	7.15	
44-16	4	2.86	40.0°	4.45	40.0°
	6	4.83	34.0	3.34	34.0
	8	7.58	32.0	2.90	31.0
	9	9.09	31.0	2.78	31.0
	12	14.70	30.0	2.58	30.0
	16	25.00	30.0	2.40	30.0
10-40	10	10.5	30.0°	2.60	30.0°
	15	22.0	29.5	2.40	29.5
	20	37.8	29.0	2.35	29.5
	24	55.2	29.0	2.30	29.5
	30	84.0	28.5	2.25	29.5
	40	149.0	28.0	2.24	29.5

¢ *Degrees current lags voltage.*

π *Voltages taken with Rectox type voltmeter.*

OVERCURRENT UNIT BURDEN DATA AT HIGH CURRENTS

TYPE KRD RELAY

AMPERE RANGE	1 - 4											
Tap Value Current	1				2				4			
Multiples of Tap Value Current	20	40	60	80	10	20	30	40	5	10	15	20
VA π	65	176	330	560	27	76.8	156	236	12.4	40	85.2	136
P.F. Angle ¢	41°	35°	27.2°	23.6°	35.6°	28.8°	23.8°	21.5°	24.3°	22.7°	19.9°	16.1°

ENERGY REQUIREMENTS – 60 CYCLES

TYPE KRC RELAY

AMPERE RANGE	TAP	VA AT TAP VALUE π	P.F. ANGLE φ	VA AT 5 AMPS. π	P.F. ANGLE φ
.5-2	.5	0.42	39.5°	27.50	43.6°
	.75	0.49	37.9	17.60	39.5
	1.0	0.57	36.9	13.00	37.8
	1.25	0.68	36.0	10.50	35.9
	1.5	0.81	36.0	8.98	35.6
	2.0	1.10	36.4	6.94	35.4
1-4	1.0	0.57	37.1°	13.30	38.1°
	1.5	0.79	36.7	8.79	36.8
	2.0	1.10	37.1	6.84	36.8
	2.5	1.46	37.9	5.90	37.4
	3.0	1.92	38.4	5.34	38.1
	4.0	3.06	39.6	4.77	39.1
2-8	2	1.68	39.8°	10.50	38.8°
	3	2.58	37.3	7.03	36.5
	4	3.75	36.1	5.87	35.8
	5	5.19	35.8	5.17	35.7
	6	7.07	35.8	4.88	36.1
	8	11.30	35.7	4.51	36.8
4-16	4	2.17	42.2°	3.37	42.0°
	6	3.20	38.0	2.22	37.8
	8	4.64	35.5	1.80	36.0
	9	5.37	35.8	1.67	35.7
	12	8.52	34.8	1.46	35.0
	16	13.8	33.7	1.33	35.0
10-40	10	6.08	34.0°	1.52	33.9°
	15	12.2	32.6	1.34	34.1
	20	20.5	31.8	1.27	34.5
	24	28.7	31.3	1.24	34.5
	30	43.4	30.4	1.19	35.4
	40	78.3	28.5	1.16	35.6

φ Degrees current lags voltage.
π Voltages taken with Rectox type voltmeter.

ENERGY REQUIREMENTS

BURDEN DATA OF OPERATING CURRENT CIRCUIT – 60 CYCLES

TYPE KRP RELAY

AMPERE RANGE	TAP	VA AT TAP VALUE π	P.F. ANGLE φ	VA AT 5 AMPS. π	P.F. ANGLE φ
.5-2	.5	0.40	36.8°	26.10	42.3°
	.75	0.45	35.3	16.70	36.9
	1.0	0.53	34.1	12.10	33.9
	1.25	0.62	33.1	9.43	33.1
	1.5	0.73	32.3	7.94	31.6
	2.0	0.96	32.1	6.06	31.1
1-4	1.0	0.53	31.1°	12.50	31.2°
	1.5	0.72	29.1	7.99	28.2
	2.0	0.96	28.7	6.09	27.8
	2.5	1.25	28.7	5.04	28.1
	3.0	1.63	29.6	4.57	28.9
	4.0	2.55	30.1	3.99	30.0
2-8	2	1.55	38.3°	9.54	37.6°
	3	2.26	35.5	6.25	34.8
	4	3.20	33.2	4.98	33.1
	5	4.39	32.8	4.40	32.7
	6	5.78	32.4	4.05	32.1
	8	9.31	31.8	3.62	32.4
4-16	4	2.05	42.8°	3.24	42.0°
	6	2.94	38.5	2.03	38.0
	8	4.09	35.7	1.59	35.7
	9	4.77	34.8	1.46	35.5
	12	7.30	33.3	1.24	34.3
	16	11.5	32.0	1.11	34.2
10-40	10	5.23	30.9°	1.33	30.8°
	15	10.5	30.3	1.15	31.3
	20	17.6	30.3	1.07	30.8
	24	24.1	29.4	1.05	29.9
	30	36.8	30.1	0.99	31.6
	40	64.9	28.9	0.97	31.9

φ Degrees current lags voltage.
π Voltages taken with Rectox type voltmeter.

of back contacts of the directional unit, or 26 ms total operating time for overcurrent unit. The total time for directional unit is 56 ms; and, since this is the longest time, 51 ms is the total operating time of the relay.

Example 2:

Let: Ipol = 20 amps.
Iop = 23.1 amps.
T (tap) = 1 amp.
$\phi i = 0$

$$Mpp = \frac{Iop\ Ipol\ Cos\ \phi}{.25}$$

$$MPP = \frac{(20)\ (23.1) = 1850}{.25}$$

Entering Fig. 5, the directional unit closing time is 12 ms, and the opening time of its back contacts is 1 ms. The total operating time for the directional unit is 12 ms.

For overcurrent unit:
Multiples of pickup $= \frac{Iop}{T} = \frac{23.1}{1} = 23.1$

Referring to Fig. 6, the overcurrent unit contact closing time is about 10 ms. Therefore, the total operating time for this unit is 13 plus 1 or 14 ms. In this case the total operating time of relay is 14 ms.

Trip Circuit

The main contacts will safely close 30 amperes at 250 volts d-c and the seal-in contacts of the indicating contactor switch will safely carry this current long enough to trip a circuit breaker.

The indicating contactor switch has a pickup of approximately 1 ampere. Its d-c resistance is 0.1 ohms.

Cylinder Unit Contacts

The moving contact assembly has been factory adjusted for low contact bounce performance and should not be changed.

The set screw in each stationary contact has been shop adjusted for optimum follow and this adjustment should not be disturbed.

SETTINGS

Overcurrent Unit (I)

The only setting required is the pickup current setting which is made by means of the connector screw located on the tap plate. By placing the connector screw in the desired tap, the relay will just close its contacts at the tap value current.

For carrier relaying the carrier trip overcurrent unit located in the type KRP, KRC or KRD relay should be set on a higher tap than the carrier start overcurrent unit located in the type KA relay at the opposite end of the line.

CAUTION Since the tap block connector screw carries operating current, be sure that the screw is turned tight.

In order to avoid opening the current transformer circuits when changing taps under load, connect the spare tap screw in the desired tap position before removing the other tap screw from the original tap position.

Directional Unit (D)

No setting is required.

INSTALLATION

The relays should be mounted on switchboard panels or their equivalent in a location free from dirt, moisture, excessive vibration and heat. Mount the relay vertically by means of the two mounting studs for projection mounting or by means of the four mounting holes on the flange for the semi-flush mounting.

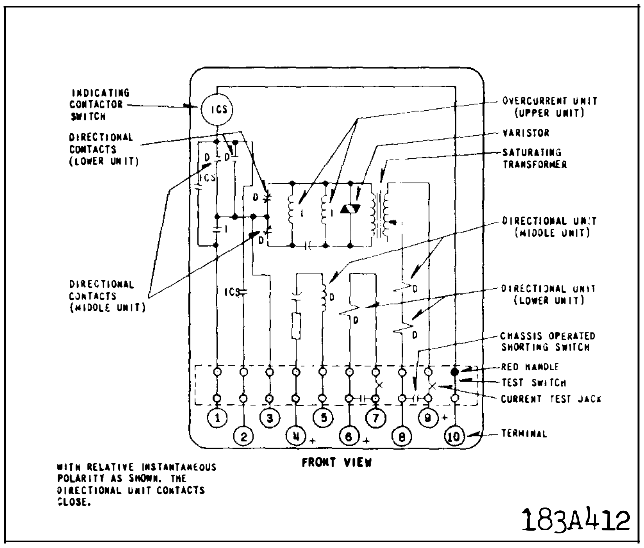


Fig. 4. Internal Schematic of the Type KRD Relay in the FT31 Case.

range, the minimum pick-up is 1 volt and 4 amperes.

Type KRC Relay

The KRC relay is designed for current polarization and has its maximum torque when the operating current leads the polarizing current by approximately 40°.

The directional unit minimum pick-up is 0.5 ampere in each winding at the maximum torque angle for the 0.5 to 2, 1 to 4, and 2 to 8 ampere range relays. For the 4 to 16 and 10 to 40 ampere range, the minimum pick-up is 1 ampere.

Type KRD Relay

The type KRD relay utilizes a directional unit similar to the KRC relay in conjunction with the directional unit and phase-shifting circuit of the KRP relay.

The current-polarized directional unit of the KRD relay operates on residual currents while the potential-polarized directional unit of the KRD relay operates on residual voltage and residual current.

For the 0.5 to 2, 1 to 4, and 2 to 8 ampere range relays, the minimum pick-up of the current polarized unit is 0.5 ampere in each winding at the maximum torque angle. The minimum pick-up for the voltage polarized unit is 1 volt and 2 amperes with the current lagging voltage by 60°.

For the 4 to 16 and the 10 to 40 ampere range relays, the minimum pick-up is 1 ampere for the current-polarized directional unit, and 1 volt and 4 amperes for the voltage-polarized directional unit.

TIME CURVES

The time curves for the KRD relay are shown in Fig. 5 and 6. Fig. 5 consists of three curves which are:

1) Directional Unit opening times for current and voltage polarized.
2) Directional Unit closing time for current and voltage polarized.
3) Directional Unit closing time for 1 volt, voltage polarized.

Fig. 6 shows the instantaneous overcurrent unit closing time.

The voltage polarized curve B begins to deviate from curve A for less than 5 volts.

Both the directional unit and the overcurrent unit must operate before the trip circuit can be completed. Hence, the unit which takes the longer time to operate determines when the breaker will be tripped. The overcurrent unit contacts cannot operate until the back contacts of directional unit open; therefore, the total time for overcurrent unit to operate is its closing time given in Fig. 6 plus the directional unit opening time given in Fig. 5. The total closing time for the directional unit is given in Fig. 5. The two examples below will serve to illustrate the use of the curves.

Example 1: Using the formulas and definition of symbols on Fig. 5, we have—

Let: Ipol = 2 amps.
Iop = 2.31
Tap Value (T) = 0.5 amp.
$\phi = 0^{\circ}$

For current polarized relay:

$$* \quad MPP = \frac{Iop\ Ipol\ Cos\ (\phi - 40)}{.25}$$

$$MPP = \frac{(2.31)\ (2) = 18.5}{.25}$$

Referring to Fig. 5 at multiples of product pickup of 18.5, the directional unit opening time is about 11 ms, and the closing time for this unit is 56 ms.

For overcurrent unit:

$$\text{Multiples of pickup} = \frac{Iop}{T} = \frac{2.31}{0.5} = 4.6$$

Entering the curve in Fig. 6 at multiples of pickup equal to 4.6, the closing time for the overcurrent is 16 ms. However, the total operating time for the overcurrent unit is 16 plus 10, which is the opening time

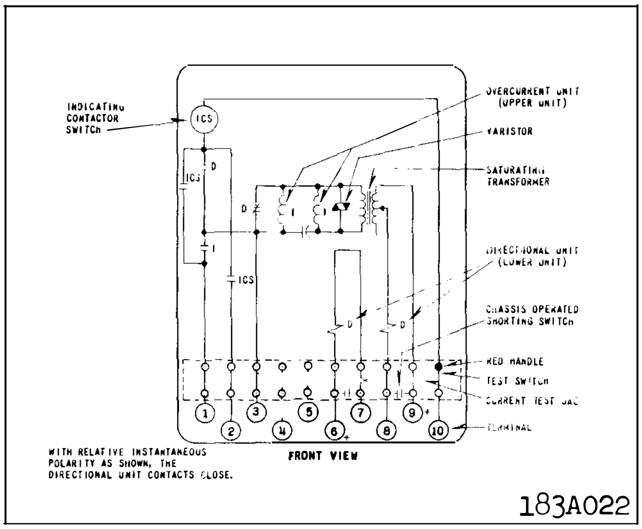


Fig. 2. Internal Schematic of the Type KRC Relay in the FT31 Case.

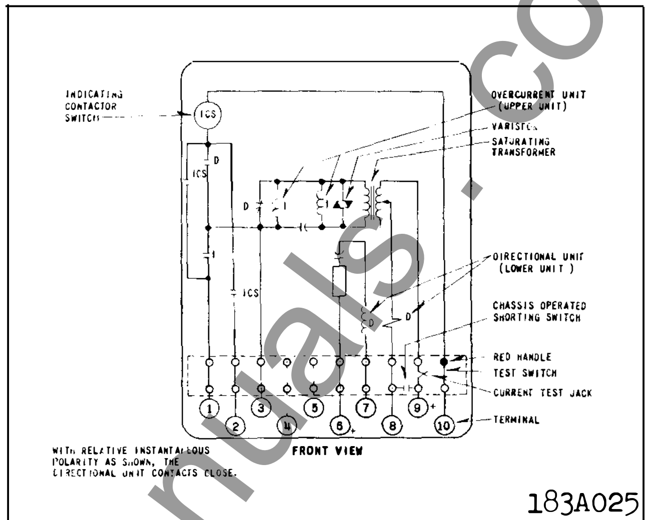


Fig. 3. Internal Schematic of the Type KRP Relay in the FT31 Case.

tional unit should pick up for a fault, this short-circuit is removed, allowing the overcurrent contact to commence closing almost simultaneously with the directional contact for high speed operation.

Overcurrent Unit Transformer

This transformer is of the saturating type for limiting the energy to the overcurrent unit at higher values of fault current and to reduce C.T. burden. The primary winding is tapped and these taps are brought out to a tap block for ease in changing the pick-up of the overcurrent unit. The use of a tapped transformer provides approximately the same energy level at a given multiple of pickup current for any tap setting, resulting in one time curve throughout the range of the relay.

Across the secondary is connected a non-linear resistor known as a varistor. The effect of the varistor is to reduce the voltage peaks applied to the overcurrent unit and phase shifting capacitor.

INDICATING CONTACTOR SWITCH UNIT (ICS)

The indicating contactor switch is a small d-c operated clapper type device. A magnetic armature, to which leaf-spring mounted contacts are attached, is attracted to the magnetic core upon energization of the switch. When the switch closes, the moving contacts bridge two stationary contacts, completing the trip circuit. Also during this operation two fingers on the armature deflect a spring located on the front of the switch, which allows the operation indicator target to drop. The target is reset from the outside of the case by a push rod located at the bottom of the cover.

The front spring, in addition to holding the target, provides restraint for the armature and thus controls the pickup value of the switch.

CHARACTERISTICS

The relays are available in the following current ranges:

Range	Taps					
0.5-2 Amps	0.5	0.75	1.0	1.25	1.5	2
1-4	1.0	1.5	2.0	2.5	3.0	4.0
2-8	2	3	4	5	6	8
4-16	4	6	8	9	12	16
10-40	10	15	20	24	30	40

The tap value is the minimum current required to just close the overcurrent relay contacts. For pick-up settings in between taps refer to the section under adjustments.

Type KRP Relay

The KRP relay is designed for potential polarization and has its maximum torque when the current lags the voltage by approximately 60 degrees. The shifting of the maximum torque angle is accomplished by the use of an internally mounted phase shifter as shown in the internal schematic.

The directional unit minimum pick-up is approximately 1 volt and 2 amperes at its maximum torque angle for the 0.5 to 2, 1 to 4, and 2 to 8 ampere range relays. For the 4 to 16 and 10 to 40 ampere

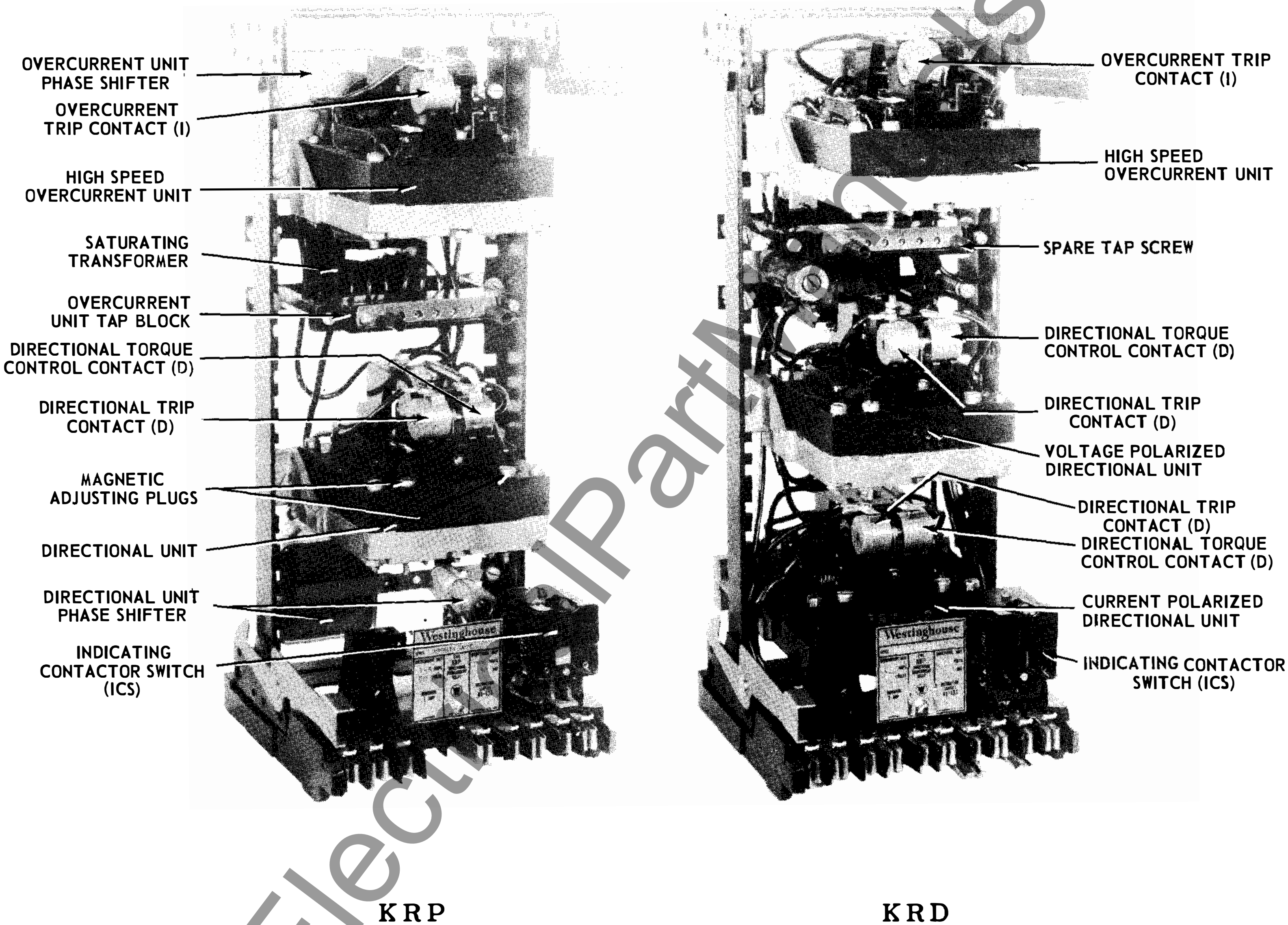


Fig. 1. Type KRP and KRD Relays without Case.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

DIRECTIONAL OVERCURRENT GROUND RELAY TYPES KRP KRC AND KRD

CAUTION Before putting relays into service, remove all blocking which may have been inserted for the purpose of securing the parts during shipment, make sure that all moving parts operate freely, inspect the contacts to see that they are clean and close properly, and operate the relay to check the settings and electrical connections.

APPLICATION

These relays are high speed ground directional overcurrent relays which are used for the protection of transmission lines and feeder circuits.

They are also used, without modification to provide directional ground fault protection in the KD carrier relaying scheme. Operation of the relays in connection with the carrier scheme is fully described * in I.L. 40-208.

The type KRP relay is used where residual voltage is available for polarizing the directional unit. The type KRC is used where this residual voltage is not available and residual current must be used. The type KRD relay is a dual polarized relay which can be polarized from a potential source, from a local ground source or from both simultaneously.

CONSTRUCTION AND OPERATION

Directional Unit (D)

The directional unit is a product induction cylinder type unit operating on the interaction between the polarizing circuit flux and the operating circuit flux.

Mechanically, the directional unit is composed of four basic components: A die-cast aluminum frame, an electromagnet, a moving element assembly, and a molded bridge.

The frame serves as the mounting structure for the magnetic core. The magnetic core which houses the lower pin bearing is secured to the frame by a locking nut. The bearing can be replaced, if necessary, without having to remove the magnetic core from the frame.

The electromagnet has two series-connected polarizing coils mounted diametrically opposite one another; two series-connected operating coils mounted diametrically opposite one another; two magnetic adjusting plugs; upper and lower adjusting plug clips, and two locating pins. The locating pins are used to accurately position the lower pin bearing, which is threaded into the bridge. The electromagnet is secured to the frame by four mounting screws.

The moving element assembly consists of a spiral spring, contact carrying member, and an aluminum cylinder assembled to a molded hub which holds the shaft. The shaft has removable top and bottom jewel bearings. The shaft rides between the bottom pin bearing and the upper pin bearing with the cylinder rotating in an air gap formed by the electromagnet and the magnetic core.

The bridge is secured to the electromagnet and frame by two mounting screws. In addition to holding the upper pin bearing, the bridge is used for mounting the adjustable stationary contact housing. The stationary contact housing is held in position by a spring type clamp. The spring adjuster is located on the underside of the bridge and is attached to the moving contact arm by a spiral spring. The spring adjuster is also held in place by a spring type clamp.

With the contacts closed, the electrical connection is made through the stationary contact housing clamp, to the moving contact, through the spiral spring out to the spring adjuster clamp.

Overcurrent Unit (I)

The overcurrent unit is similar in construction to the directional unit. The time phase relationship of the two air gap fluxes necessary for the development of torque is achieved by means of a capacitor connected in series with one pair of pole windings.

The normally-closed contact of the directional unit is connected across one pair of pole windings of the overcurrent unit as shown in the internal schematics. This arrangement short-circuits the operating current around the pole windings; preventing the overcurrent unit from developing torque. If the direc-

SUPERSEDES I.L. 41-137J
*Denotes change from superseded issue.

EFFECTIVE NOVEMBER 1974

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE KRD-4 DIRECTIONAL OVERCURRENT GROUND RELAY

CAUTION: Before putting relays into service, remove all blocking which may have been inserted for the purpose of securing the parts during shipment, make sure that all moving parts operate freely, inspect the contacts to see that they are clean and close properly, and operate the relay to check the settings and electrical connections.

APPLICATION

The KRD-4 relay is a high speed directional overcurrent relay which is used for the protection of transmission lines and feeder transmission lines and feeder circuits. These relays are dual polarized relays which can be polarized from a potential source, from a local ground source, or from both simultaneously.

They are also used, without modifications to provide directional ground fault protection in the KD-4 carrier relaying scheme. Operation of the relays in connection with the carrier scheme is fully described in I.L. 41-911.

CONSTRUCTION

The type KRD-4 directional overcurrent ground relay consists of a dual polarized directional unit, an instantaneous overcurrent unit, and an indicating contactor switch. The principal parts of the relay and their location are shown in Fig. 1 to 3.

A. DIRECTIONAL UNIT (D)

The directional unit of the KRD-4 consists of an induction cylinder unit, phase shifting network, and a de-coupling network.

1. Induction Cylinder Unit

The cylinder unit is a product type in which torque is produced by the phase relationship of an operating flux and a polarizing flux on an aluminum cylinder supporting a moving contact arm. A contact opening torque or a contact closing torque is produced depending upon the phase relationship between the two fluxes.

The cylinder unit consists of three basic assemblies: an electromagnet assembly, a moving element assembly, and a stationary closing assembly.

The electromagnet assembly consists of an electromagnet, an adjustable magnetic core, two magnetic adjusting plugs, lower bearing pin, and a die-casted aluminum frame. The moving element assembly consists of a spiral spring, contact carrying member, and an aluminum cylinder which is assembled to a molded hub which holds the shaft. The shaft has removable top and bottom jewel bearings. The stationary contact assembly consists of a molded bridge, upper bearing pin, stationary contact housing and spring adjuster is located on the underside of the bridge and is held in place by a spring type clamp. It is attached to the moving contact arm by a spiral spring.

The electromagnet has four poles, two operating poles and two polarizing poles. Each pair of poles are diametrically opposite each other and are excited by series connected coils. (Two sets of series connected coils are used to excite the polarizing poles, one set for current polarizing and the other set for voltage polarizing). The electromagnet is permanently mounted to the frame in such a manner that an air gap exists between the pole faces of the electromagnet and the magnetic core. The aluminum cylinder of the moving element assembly rotates in this air gap on the upper and lower pin bearing.

With the contacts closed, the electrical connection is made through the stationary contact housing clamp, then the moving contact, through the spiral spring out to the spring adjusted clamp.

2. Phase Shifting Network

The phase shifting network consists of a resistor, capacitor and reactor in the polarizing circuit of the directional unit, and a saturable shunt in the operating circuit.

3. De-Coupling Network

The de-coupling network consists of an air gap

SUPERSEDES I.L. 41-137.3D
*Denotes change from superseded issue.

EFFECTIVE JUNE 1972

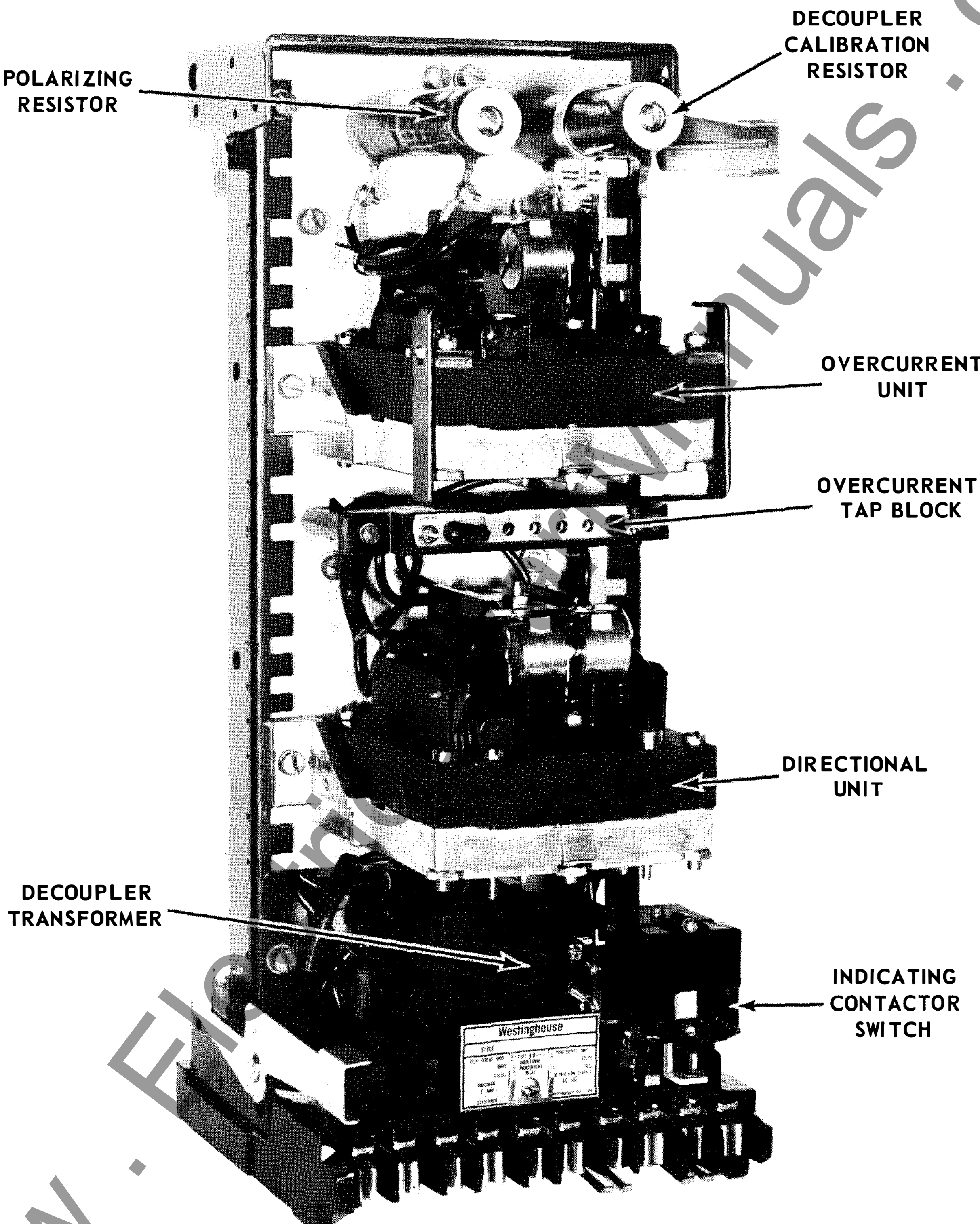


Fig. 1. Type KRD-4 Relay (Front View).

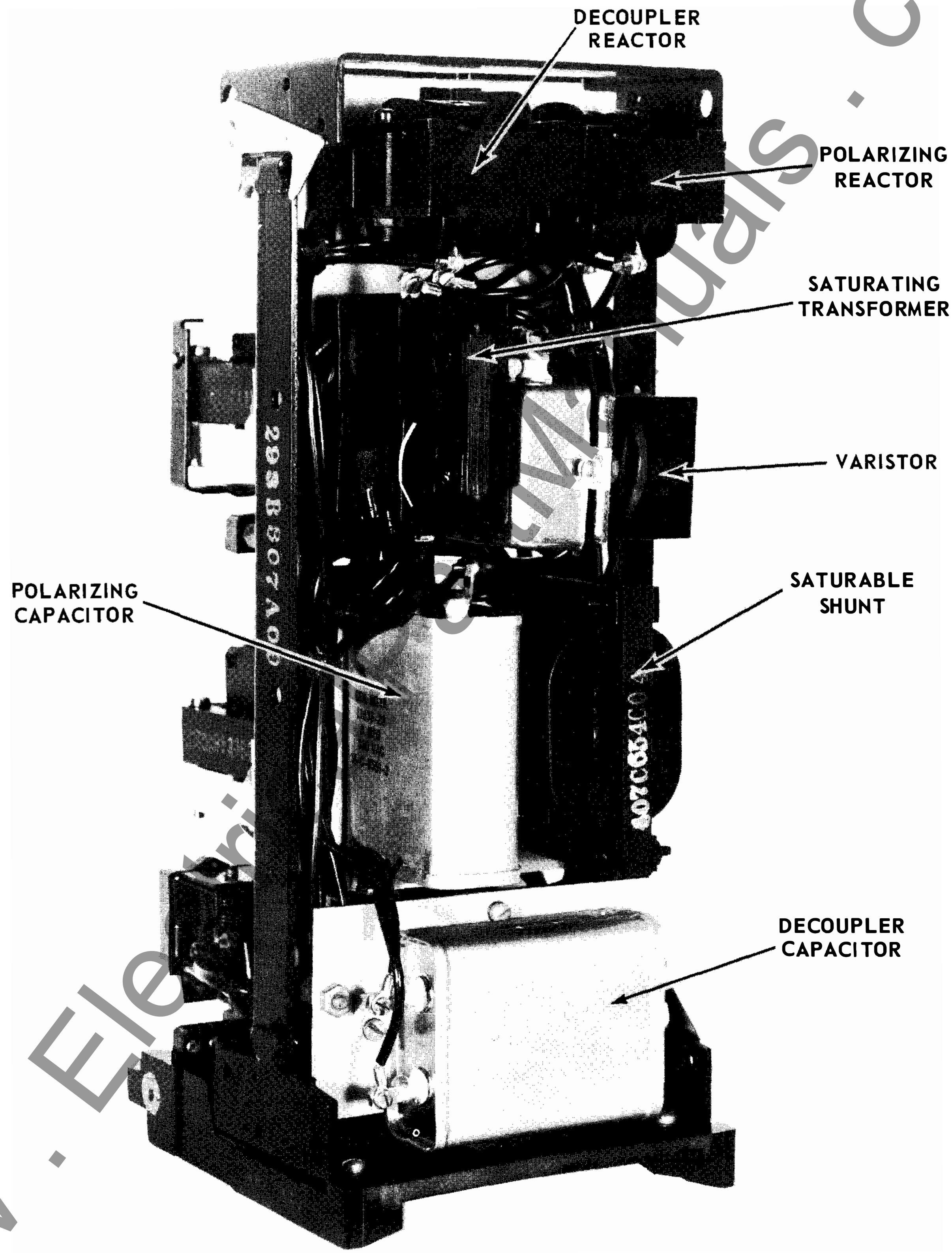


Fig. 2. Type KRD-4 Relay (Rear View).

transformer, capacitor, reactor, and resistor. Electrically this network is equivalent to the polarizing circuit of the induction cylinder unit and is utilized to minimize the coupling between the current and potential polarized sources.

B. INSTANTANEOUS OVERCURRENT UNIT (I)

The instantaneous overcurrent unit consists of an induction cylinder unit, capacitor, varistor, and a transformer. The components are connected such that a contact closing torque is produced when the current exceeds a specified value.

1. Cylinder Unit

The cylinder unit is similar in construction to the cylinder unit of the directional unit except that all coils are similar. The phase relationship of the two air gap fluxes necessary for the development of torque is achieved by means of a capacitor connected in series with one pair of pole windings.

2. Transformer

The transformer is a saturating type consisting of a tapped primary winding and a secondary winding. A varistor is connected across the secondary winding to reduce the voltage peaks applied to the cylinder unit and phase shifting capacitor.

C. INDICATING CONTACTOR SWITCH (ICS)

The indicating contactor switch is a small d-c operated clapper type device. A magnetic armature to which leaf-spring mounted contacts are attached, is attracted to the magnetic core upon energization of the switch. When the switch closes, the moving contacts bridge two stationary contacts, completing the trip circuit. Also during this operation two fingers on the armature deflect a spring located on the front of the switch, which allows the operation indicator target to drop. The target is reset from outside of the case by a push rod located at the bottom of the cover.

The front spring, in addition to holding the target, provides restraint for the armature and thus controls the pickup value of the switch.

OPERATION

The type KRD-4 relay is connected to the protected transmission line as shown in Fig. 4. In such a connection, the relay operates to disconnect the line for ground faults of a definite magnitude that are flowing in a specified direction.

The directional unit of the relay compares the phase angle between the fault current and the polarizing quantities of the system and either produces a contact closing torque for faults in the trip direction or produces a contact opening torque for faults in the non-trip direction. Relay operation occurs when both the directional unit and the instantaneous overcurrent unit close their contacts. Hence, the fault current must be greater than the tap setting of the overcurrent unit.

For faults in the non-trip direction, a contact opening torque is produced by the directional unit such that the normally closed contact of this unit shorts out a pair of windings on the overcurrent unit. This prevents the overcurrent unit from developing torque to close its contacts. For faults in the trip direction, the directional unit will pickup and remove this short circuit, allowing the overcurrent contact to commence closing almost simultaneously with the directional contact for high speed operation.

CHARACTERISTICS

The relays are available in the following current ranges:

Range	Taps					
0.5-2 Amps.	0.5	0.75	1.0	1.25	1.5	2
1-4	1.0	1.5	2.0	2.5	3.0	4.0
4-16	4.0	6.0	8.0	9.0	12	16
10-40	10	15	20	25	30	40

The tap value is the minimum current required to just close the overcurrent relay contacts. For pickup settings in between taps refer to the section under SETTINGS.

The KRD-4 relay is designed for dual polarizing and can be polarized from a potential source, a local ground source or from both simultaneously. When the relay is potential polarized, the maximum torque of the relay occurs when the operating current lags the polarizing voltage by approximately 65 degrees. When the relay is current polarized, the maximum torque of the relay occurs when the operating current is in phase with the polarizing current.

TIME CURVES

The time curves for the KRD-4 relay are shown in Fig. 5 and 6. Fig. 5 includes three curves which are:

1. Directional Unit opening times for current, voltage, or dual polarized.
2. Directional unit closing times for current, voltage or dual polarized.
3. Directional unit closing time for 5 volts voltage polarized.

Fig. 6 shows the instantaneous overcurrent unit closing time.

The voltage polarized curve (curve B in Fig. 5) begins to deviate from curve A at about 10 volts polarization

Both the directional unit and the overcurrent unit must operate before the trip circuit can be completed. Hence, the unit which takes the longer time to operate determines when the breaker will be tripped. The overcurrent unit contacts cannot operate until the back contacts of the directional unit open; therefore, the total time for the overcurrent unit to operate is its closing time given in Fig. 6 plus the directional unit's opening time given in Fig. 5. The total closing time for the directional unit is given in Fig. 5. The two examples below will serve to illustrate the use of the curves.

(Example One) definition of symbols are shown on Fig. 5.

let: I_{pol} = 1.5 amp.

I_{op} = 3 amp

tap value (T) = 0.5 amp.

$\emptyset = 0°$

for a current polarized relay:

$$MPP = \frac{I_{op} I_{pol} \cos \emptyset}{0.25}$$

$$MPP = \frac{(3)\ (1.5)}{0.25} = 18$$

Entering the curves in Fig. 5 at multiples of product pickup of 18 the directional unit opening time is 4 ms, and the closing time for this unit is 33 ms.

For the overcurrent unit:

$$\text{multiples of pickup} = \frac{I_{op}}{T}$$

$$= \frac{3}{0.5} = 6$$

Entering the curve in Fig. 6 at multiples of pickup equal to 6 the closing time for the overcurrent is 14 ms. However, the total operating time for the overcurrent unit is 14 plus 4 ms, which is the opening time of back contacts of the directional unit, or 18 ms total operating time for the overcurrent unit. The total operating time for the directional unit is 33 ms; and since this is the longest time, 33 ms is the total operating time of the relay.

(Example Two)

let: I_{pol} = 15 amp

I_{op} = 25 amp

T (tap) = 1 amp.

$\emptyset = 0$

$$MPP = \frac{I_{op} I_{pol} \cos \emptyset}{0.25}$$

$$MPP = 1500$$

referring to Fig. 5 the directional unit closing time is 8 ms, and the opening time of its back contacts is 3 ms. The total operating time for the directional unit is 8 ms.

For the overcurrent unit:

$$\text{multiples of pick up} = \frac{I_{op}}{T}$$

$$= 25$$

referring to Fig. 6 the overcurrent unit contact closing time is 10 ms. Therefore, the total operating time for this unit is 10 + 3 ms or 13 ms. In this case the total operating time of the relay is 13 ms.

Trip Circuit

The main contacts will safely close 30 amperes at 250 volts d-c and the seal-in contacts of the indicating contactor switch will safely carry this current long enough to trip a circuit breaker.

The indicating contactor switch has a pickup of approximately 1 ampere. Its d-c resistance is 0.1 ohms.

Cylinder Unit Contacts

The moving contact assembly has been factory adjusted for low contact bounce performance and should not be changed.

The set screw in each stationary contact has been shop adjusted for optimum follow and this adjustment should not be disturbed.

* TABLE I

DIRECTIONAL UNIT SENSITIVITY

Polarizing Quantity	Values for Min. Pickup		Phase Angle Relationship
	Volts	Amperes	
VOLTAGE	1	0.7 ★	I lagging V by 65°
	1	1.5 ★	I In Phase with V
CURRENT		0.5 ★	In-phase

★ or less

The energization quantities are input quantities at the relay terminals. Maximum torque angle.

TABLE II

DIRECTIONAL UNIT CALIBRATION

Relay Rating	Current Amperes	Both Plugs In Condition	Adjustment
All Ranges	80	Spurious torque in contact closing direction (left front view)	Right (front view Plug Screwed out until spurious torque is reversed.
All Ranges	80	Spurious torque in contact opening direction (Right front view) (Contact remain Open)	Left (front view) Plug screwed out until spurious torque is in contact closing directions. Then the plug is screwed in until spurious torque is reversed.

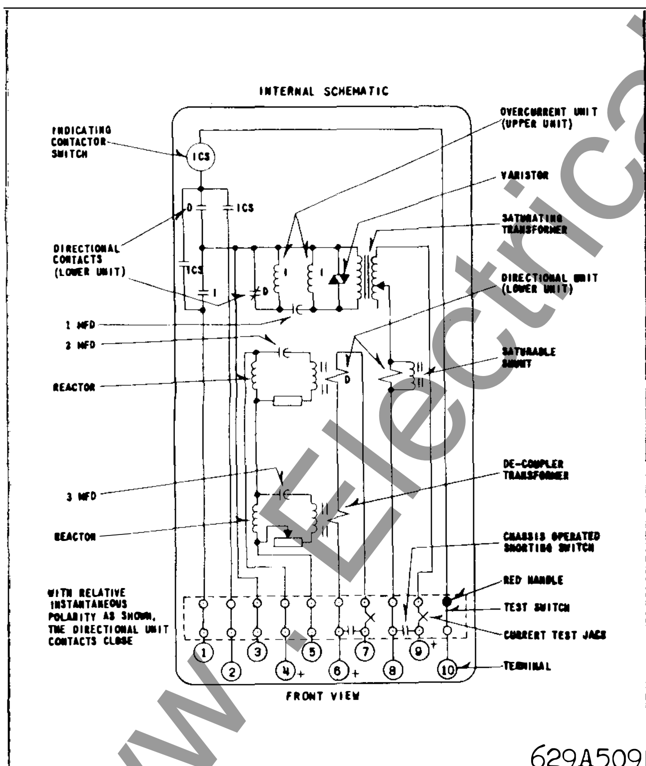


Fig. 3. Internal Schematic of the Type KRD-4 Relay in the Type FT31 Case.

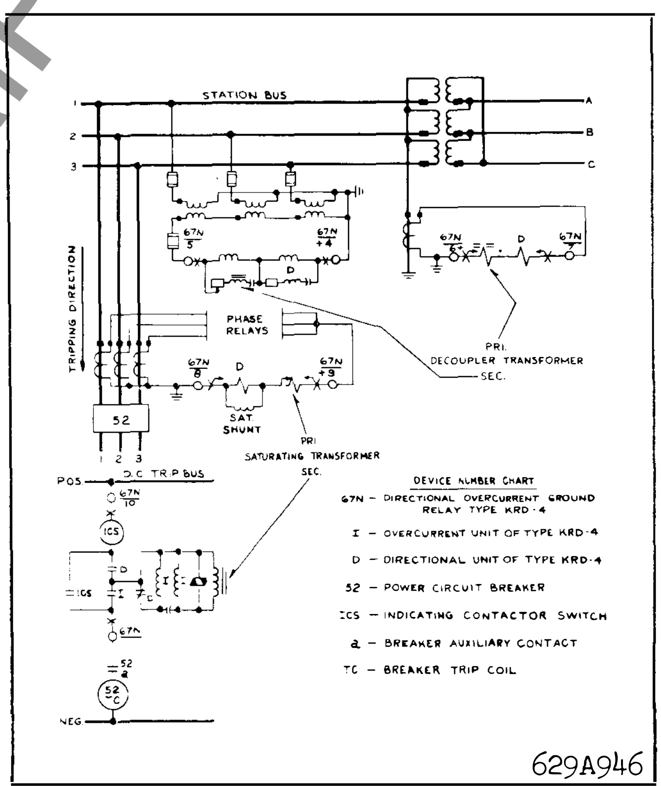


Fig. 4. External Schematic for the Type KRD-4 Relay.

SETTINGS

Overcurrent Unit (I)

The only setting required is the pickup current setting which is made by means of the connector screw located on the tap plate. By placing the connector screw in the desired tap, the relay will just close its contacts at the tap value current.

If adjustment of pick-up current in between tap settings is desired insert the tap screw in the next lowest tap setting and adjust the spring as described. It should be noted that this adjustment results in a slightly different time characteristic curve and burden.

For carrier relaying the carrier trip overcurrent unit located in the type KRD-4 relay should be set higher than the carrier start overcurrent unit located in the type KA-4 relay at the opposite end of the line.

CAUTION: Since the tap block connector screw carries operating current, be sure that the screw is turned tight.

In order to avoid opening the current transformer circuits when changing taps under load, connect the spare tap screw in the desired tap position before removing the other tap screw from the original tap position.

ENERGY REQUIREMENTS

BURDEN DATA OF OPERATING CURRENT CIRCUIT - 60 CYCLES

AMPERE RANGE	TAP	VA AT TAP VALUE	P.F. ANGLE Ø	VA AT 5 AMPS	P.F. ANGLE Ø
.5-2	.5	.23	54°	47	52°
	.75	.52	54°	36	52.5°
	1.0	.94	54°	31	53°
	1.25	1.56	54°	28	53.5°
	1.5	2.17	54°	26.5	54°
	2.0	3.88	54°	24	55°
1-4	1.0	1.3	52°	31.5	51°
	1.5	2.85	52°	27.3	51.5°
	2.0	5.2	52°	25.0	52°
	2.5	7.75	52°	24.2	52.5°
	3.0	11.4	52°	23.8	53
	4.0	10.6	52°	23.3	53.5°
4-16	4	5.6	43°	610†	53°
	6	10.8	46°	570†	54°
	8	17.6	47°	560†	54°
	9	22.5	48°	550†	55°
	12	39.5	50°	550†	56°
	16	69	52°	550†	56°
10-40	10	28	49°	545†	50°
	15	61	51°	540†	51°
	20	108	53°	535†	52°
	25	169	54°	530†	53°
	30	252	56°	525†	53°
	40	432	57°	525†	53°

† VA at 50 Amperes.

DIRECTIONAL UNIT POLARIZING CIRCUIT BURDEN

CIRCUIT	RATING	VOLT AMPERES△	POWER FACTOR ANGLE Ø
Current	230†† amperes	1.20	3° Lag
Voltage	208††† volts	21.0	28° Lead

Ø Degrees current leads or lags voltage at 120 volts on voltage polarized units and 5 amperes on current polarized units.

△ Burden of voltage polarized unit taken at 120 volts. Burden of current polarized units taken at 5 amperes.

†† One second rating.

††† 30 second rating. The 10 second rating is 345 volts. The continuous rating is 120 volts.

Directional Unit (D)

No setting is required.

INSTALLATION

The relays should be mounted on switchboard panels or their equivalent in a location free from dirt, moisture, excessive vibration and heat. Mount the relay vertically by means of the two mounting studs for projection mounting or by means of the four mounting holes on the flange for the semi-flush mounting. Either of the studs or the mounting screws may be utilized for grounding the relay. The electrical connections may be made directly to the terminals by means of screws for steel panel mounting or to terminal studs furnished with the relay for thick panel mounting. The terminal studs may be easily removed or inserted by locking two nuts on the studs and then turning the proper nut with a wrench.

For detailed information, refer to I.L. 41-076.

ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory. Upon receipt of the relay, no customer adjustments, other than those covered under "SETTINGS," should be required.

Acceptance Check

The following check is recommended to insure that the relay is in proper working order.

Overcurrent Unit (I)

1. Contact Gap - The gap between the stationary and moving contacts with the relay in the de-energized position should be approximately .020."
2. Minimum Trip Current - The normally-closed contact of the directional unit should be blocked open when checking the pick-up of the overcurrent unit.

   The pick-up of the overcurrent unit can be checked by inserting the tap screw in the desired tap hole and applying rated tap value current. The contact should close with ±5% of tap value current.

Directional Unit (D)

1. Contact Gap - The gap between the stationary contact and moving contact with the relay in the de-energized position should be approximately .020."
2. Sensitivity - The respective directional units should trip with value of energization and phase angle relationships as indicated in Table 1.
3. * Spurious Torque Adjustments — There should be no spurious closing torques when the operating circuits are energized per Table 2.
4. Coupling - Apply 20 amperes to terminals 6 and 7. Measure voltage across terminals 4 and 5. Should be less than 20 volts.

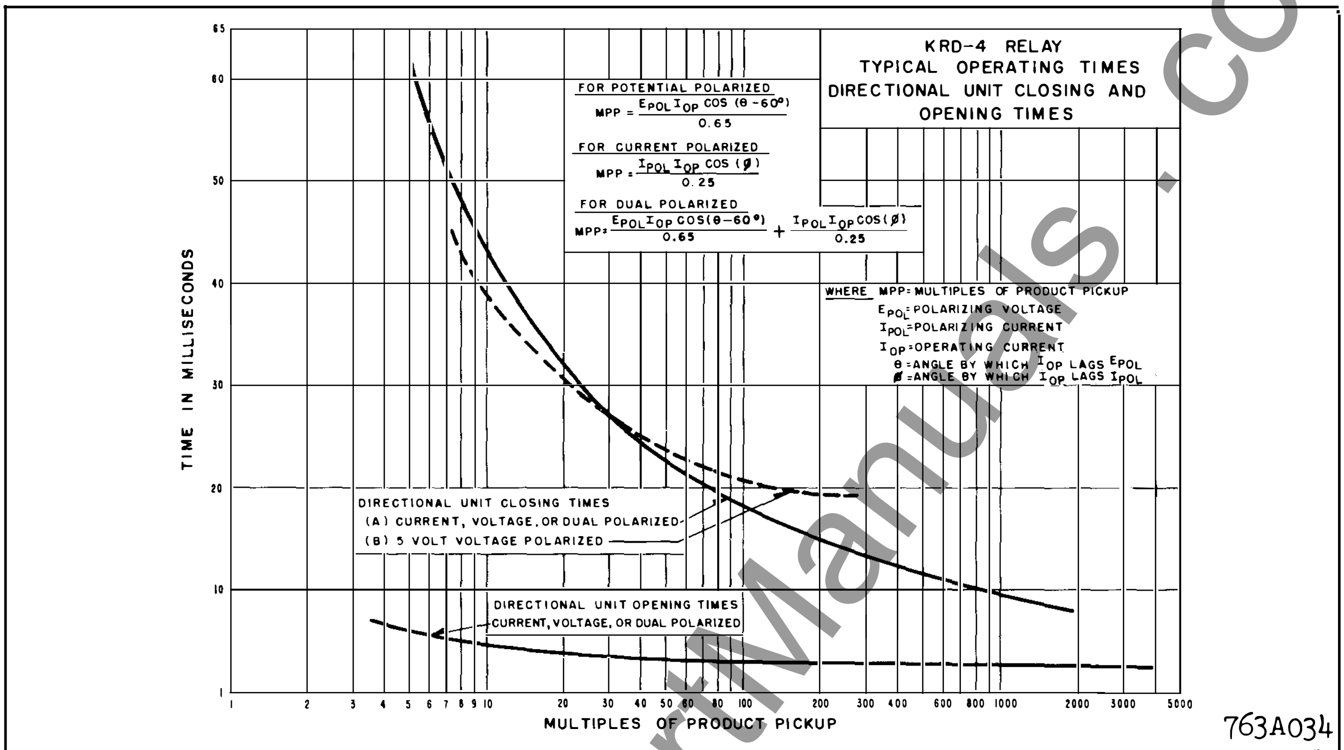


Fig. 5. Typical Time Curves for the Directional Unit.

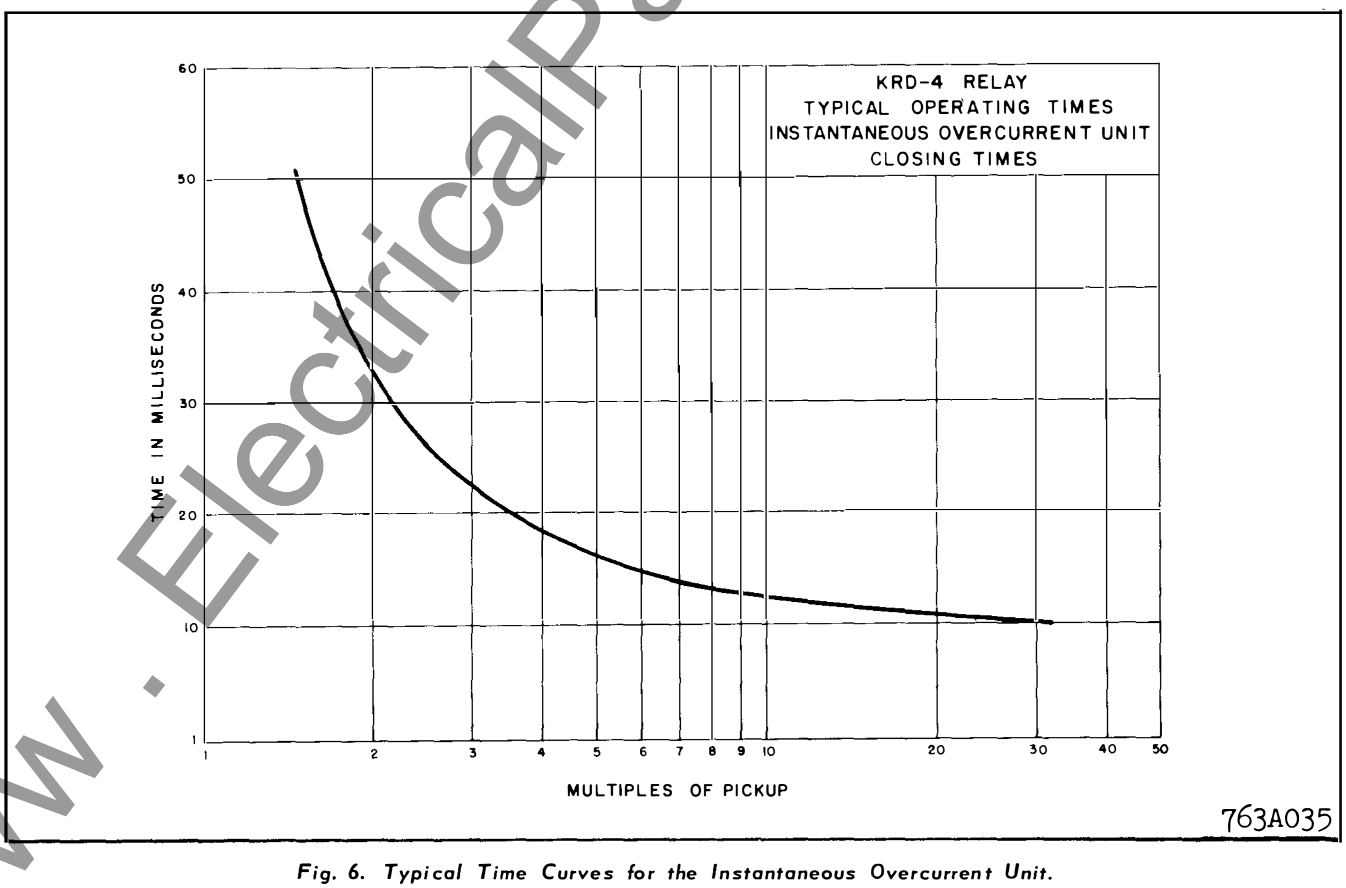


Fig. 6. Typical Time Curves for the Instantaneous Overcurrent Unit.

Indicating Contactor Switch (ICS)

Close the main relay contacts and pass sufficient d-c current through the trip circuit to close the contacts of the ICS. This value of current should be between 1 and 1.2 amperes. The indicator target should drop freely.

The contact gap should be approximately 5/64'' between the bridging moving contact and the adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously.

ROUTINE MAINTENANCE

All relays should be inspected periodically and the operation should be checked at least once every year or at such other time intervals as may be dictated by experience to be suitable to the particular application.

All contacts should be periodically cleaned. A contact burnisher S#182A836H01 is recommended for this purpose. The use of abrasive material for cleaning is not recommended because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact.

Calibration

Use the following procedure for calibrating the relay if the relay has been taken apart for repairs or the adjustments have been disturbed. This procedure should not be used unless it is apparent that the relay is not in working order. (See "Acceptance Check").

Overcurrent Unit (I)

1. The upper pin bearing should be screwed down until there is approximately .025 clearance between it and the top of shaft bearing. The upper pin bearing should then be securely locked in position with the lock nut. The lower bearing position is fixed and cannot be adjusted.

2. The contact gap adjustment for the overcurrent unit is made with the moving contact in the reset position, e.g., against the right side of the bridge. Advance the stationary contact until the contacts just close. Then back off the stationary contact 2/3 of one turn for a gap of approximately .020''. The clamp holding the stationary contact housing need not be loosened for the adjustment since the clamp utilizes a spring-type action in holding the stationary contact in position.

3. The sensitivity adjustment is made by varying the tension of the spiral spring attached to the moving element assembly. The spring is adjusted by placing a screwdriver or similar tool into one of the notches located on the periphery of the spring adjuster and rotating it. The spring adjuster is located on the underside of the bridge and is held in place by a spring type clamp that does not have to be loosened prior to making the necessary adjustments.

Before applying current, block open the normally-closed contact of the directional unit. Insert the tap screw in the minimum value tap setting and adjust the spring such that the contacts will close as indicated by a neon lamp in the contact circuit when energized with the required current. The pick up of the overcurrent unit with the tap screw in any other tap should be within ±5% of tap value.

Directional Unit (D)

1. The upper bearing screw should be screwed down until there is approximately .025 clearance between it and the top of the shaft bearing. The upper pin bearing should then be securely locked in position with the lock nut.

2. **Contact Gap.** Adjustment for the directional unit is made with moving contact in the reset position, i.e., against the right side of the bridge. Advance the right hand stationary contact until the contacts just close. Then advance the stationary contact an additional one-half turn.

Now move the in the left-hand stationary contact until it just touches the moving contact. Then back off the stationary contact 2/3 of one turn for a contact gap of approximately .020''. The clamp holding the stationary contact housing need not be loosened for the adjustment since the clamp utilizes a spring-type action in holding the stationary contact in position.

3. **Sensitivity.** Insert tap screw of overcurrent unit in highest tap. The sensitivity adjustment is made by varying the tension of the spiral spring attached to the moving element assembly. The spring is adjusted by placing a screwdriver or similar tool into one of the notches located on the periphery of the spring adjuster and rotating it. The spring adjuster is located on the underside of the bridge and is held in place by a spring type clamp that does not have to be loosened prior to making the necessary adjustments.

The spring is to be adjusted such that the contacts will close with .5 amperes flowing into terminal 6 and out terminal 8 with terminals 7 and 9 jumped together. (Use 0.7 Amps for 4-16 and 10-40 Amps.)

4. **De-Coupling Adjustment.** Connect high resistance, low reading voltmeter across terminals 4 and 5. Pass 80 amperes into terminals 6 and 7 and adjust top right hand resistor (front view) until a minimum voltage is obtained. Use care not to overheat relay during test.

5. **Core Adjustment.** Apply 10 amperes to terterminals 8 and 9 with all other terminals open circuited, Adjust core such that the contacts remain open. The core can be adjusted by the use of a screwdriver in the slots in the bottom of the cylinder unit.

6. **Plug Adjustment.** Apply current to terminals 8 and 9 with all other terminals open circuited. Plug adjustment is then made per Table II such that the spurious torques are reversed. The plugs are held in position by upper and lower plug clips. These clips need not be disturbed in any manner when making the necessary adjustment.

Indicating Contact Switch (ICS)

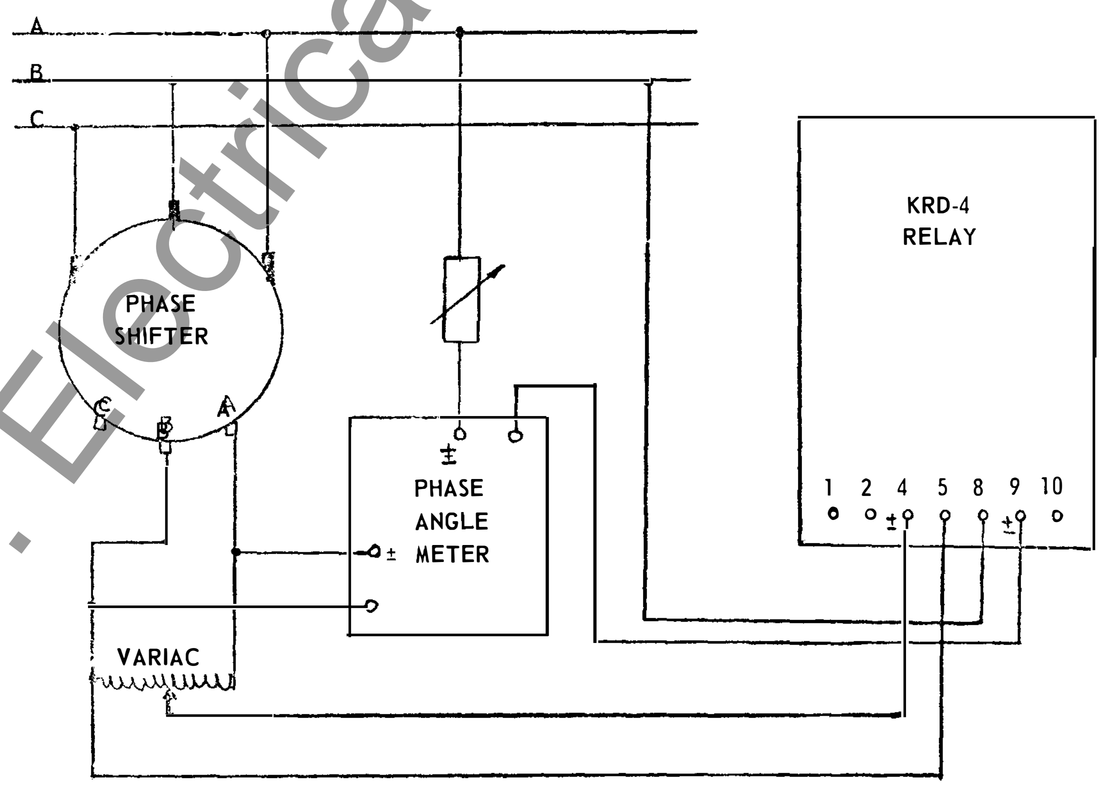
Adjust the contact gap for approximately 5/64" (-1/64", +0).

Close the main relay contacts and check to see that the relays pick up and the target drops between 1 and 1.2 amperes d-c.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, interchangeable parts can be furnished to the customers who are equipped for doing repair work. When ordering parts always give the complete nameplate data.

KRD-4 RELAY
TEST CIRCUIT



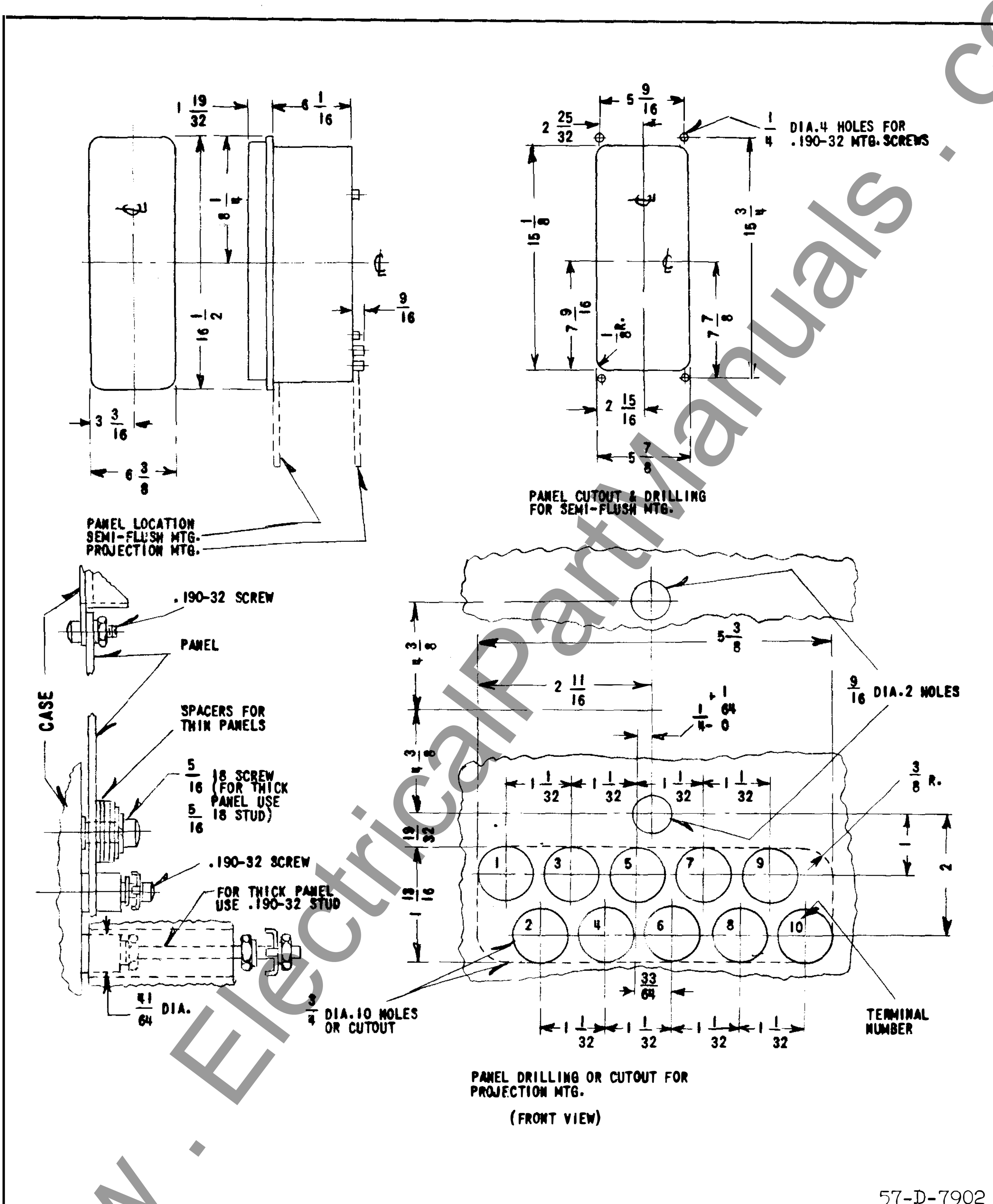


Fig. 7. Outline and Drilling Plan for the Type KRD-4 Relay in the FT31 Case.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE KRV DIRECTIONAL OVERCURRENT RELAY

FOR PHASE PROTECTION

CAUTION Before putting relays into service, remove all blocking which may have been inserted for the purpose of securing the parts during shipment, make sure that all moving parts operate freely, inspect the contacts to see that they are clean and close properly, and operate the relay to check the settings and electrical connections.

APPLICATION

These relays are high speed phase directional overcurrent relays which are used for the protection of transmission lines and feeder circuits.

CONSTRUCTION AND OPERATION

The Type KRV relay consists of a directional unit (D), an auxiliary switch (CS-1), an instantaneous unit (I), an instantaneous overcurrent unit transformer, and an indicating contactor switch (ICS). The principle component parts of the relay and their location are shown in Figs. 1 and 2.

Directional Unit (D)

The directional unit is a product induction cylinder type unit operating on the interaction between the polarizing circuit flux and the operating circuit flux.

Mechanically, the directional unit is composed of four basic components: A die-cast aluminum frame, an electromagnet, a moving element assembly, and a molded bridge.

The frame serves as the mounting structure for the magnetic core. The magnetic core which houses the lower pin bearing is secured to the frame by a spring and snap ring. This is an adjustable core which has a .025 inch flat on one side and is held in its adjusted position by the clamping action of two compressed springs. The bearing can be replaced, if necessary, without having to remove the magnetic core from the frame.

The electromagnet has two series-connected polarizing coils mounted diametrically opposite one another, two series-connected operating coils mounted diametrically opposite one another; two magnetic adjusting plugs; upper and lower adjusting plug clips, and two locating pins. The locating pins are used to accurately position the lower pin bearing, which is mounted on the frame, with respect to the upper pin bearing, which is threaded into the bridge. The electromagnet is secured to the frame by four mounting screws.

The moving element assembly consists of a spiral spring, contact carrying member, and an aluminum cylinder assembled to a molded hub which holds the shaft. The shaft has removable top and bottom jewel bearings. The shaft rides between the bottom pin bearing and the upper pin bearing with the cylinder rotating in an air gap formed by the electromagnet and the magnetic core.

The bridge is secured to the electromagnet and frame by two mounting screws. In addition to holding the upper pin bearing, the bridge is used for mounting the adjustable stationary contact housing. The stationary contact housing is held in position by a spring type clamp. The spring adjuster is located on the underside of the bridge and is attached to the moving contact arm by a spiral spring. The spring adjuster is also held in place by a spring type clamp.

With the contacts closed, the electrical connection is made through the stationary contact housing clamp, to the moving contact, through the spiral spring out to the spring adjuster clamp.

Instantaneous Overcurrent Unit (I)

The instantaneous overcurrent unit is similar in construction to the directional unit. The time phase relationship of the two air gap fluxes necessary for the development of torque is achieved by means of a capacitor connected in series with one pair of pole windings.

SUPERSEDES I.L. 41-137.2C
*Denotes change from superseded issue.

EFFECTIVE FEBRUARY 1973

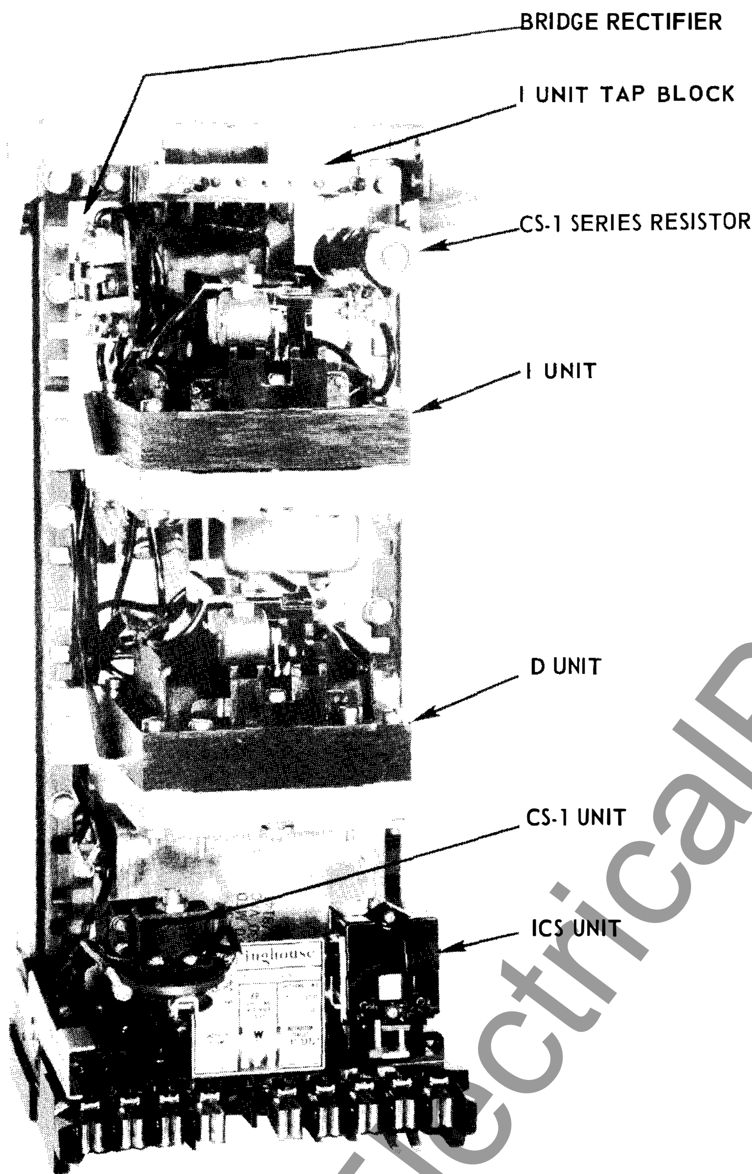


Fig. 1. Type KRV Relay Without Case (Front View)

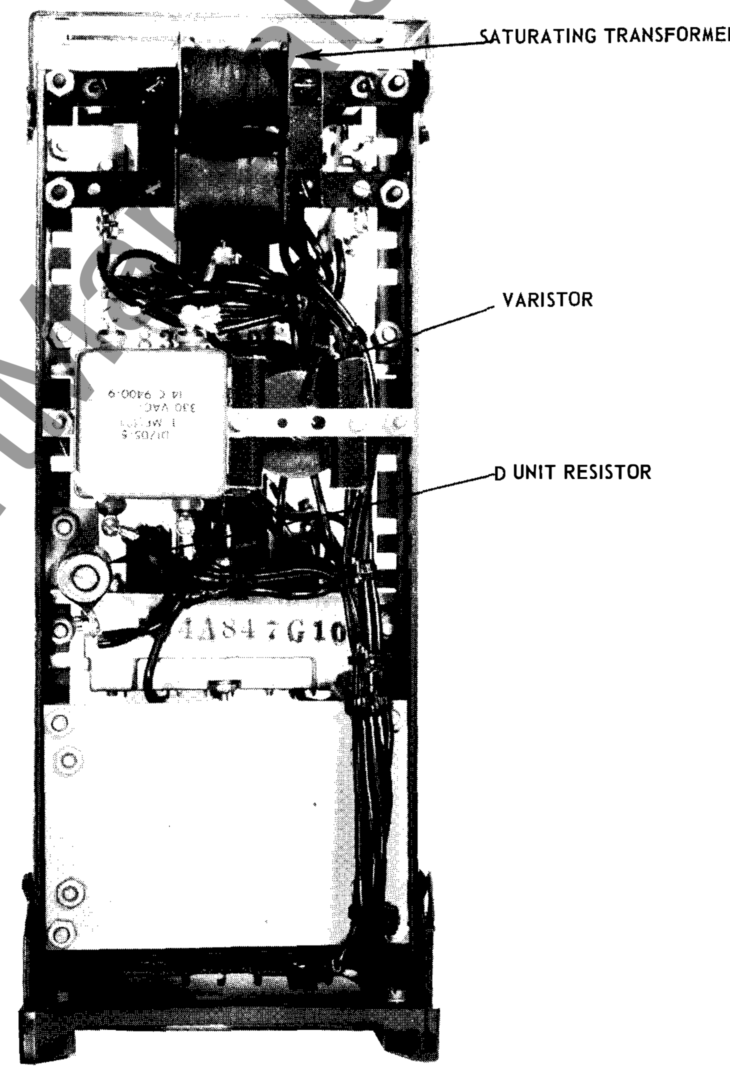


Fig. 2. Type KRV Relay Without Case (Rear View)

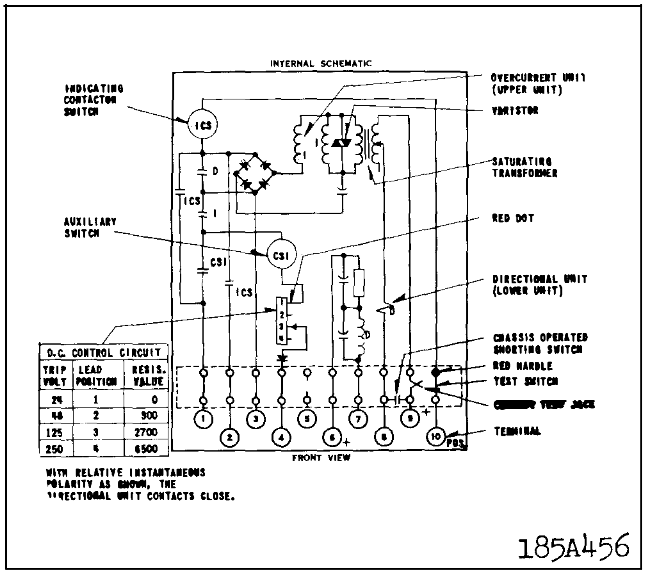


Fig. 3. Internal Schematic of the Type KRV Relay in the Type FT31 Case.

Instantaneous Overcurrent Unit Transformer

This transformer is of the saturating type for limiting the energy to the instantaneous overcurrent unit at higher values of fault current and to reduce C.T. burden. The primary winding is tapped and these taps are brought out to a tap block for ease in changing the pick-up of the instantaneous overcurrent unit. The use of a tapped transformer provides approximately the same energy level at a given multiple of pick-up current for any tap setting, resulting in one time curve throughout the range of the relay.

Across the secondary is connected a non-linear resistor known as a varistor. The effect of the varistor is to reduce the voltage peaks applied to the overcurrent unit and phase shifting capacitor.

Auxiliary Switch (CS-1)

The auxiliary switch is a small solenoid type d.c. switch. A cylindrical plunger, with a silver disc mounted on its lower end, moves in the core of the solenoid. As the plunger travels upward, the disc bridges the silver stationary contacts. A tapped resistor is used to enable one to use the contactor switch on a 24, 48, 125 or 250 volt d.c. system connected per Fig. 6. The operation of the CS-1 switch is controlled by the directional contact (D) and the I contact. It's function is to insure coordination between the directional contact (D) and the I contact to prevent tripping on reversed faults (where the directional contact was closed on load).

Indicating Contactor Switch (ICS)

The d-c indicating contactor switch is a small clapper type device. A magnetic armature, to which leaf-spring mounted contacts are attached, is attracted to the magnetic core upon energization of the switch. When the switch closes, the moving contacts bridge two stationary contacts, completing the trip circuit. Also during this operation two fingers on the armature deflect a spring located on the front of the switch, which allows the operation indicator target to drop.

The front spring, in addition to holding the target, provides restraint for the armature and thus controls the pick-up value of the switch.

CHARACTERISTICS

The relays are available in the following current ranges:

Instantaneous Overcurrent Unit (I)

Range	Taps					
0.5-2 Amps	0.5	0.75	1.0	1.25	1.5	2
1-4	1.0	1.5	2.0	2.5	3.0	4.0
2-8	2	3	4	5	6	8
4-16	4	6	8	9	12	16
10-40	10	15	20	24	30	40
20-80	20	30	40	48	60	80

The tap value is the minimum current required to just close the relay contacts.

The time vs. current characteristics for the instantaneous overcurrent unit is shown in Fig. 4.

The time vs. current characteristics for the directional unit is shown in Fig. 5.

Trip Circuit

The relay contacts will safely close 30 amperes at 250 volts d.c. and the seal-in contacts of the indicating contactor switch will safely carry this current long enough to trip a circuit breaker.

Trip Circuit Constants

The indicating contactor switch has a pickup of approximately 1 ampere. Its d-c resistance is 0.1 ohms.

Auxiliary Switch (CS-1)

The auxiliary switch has a d-c resistance of

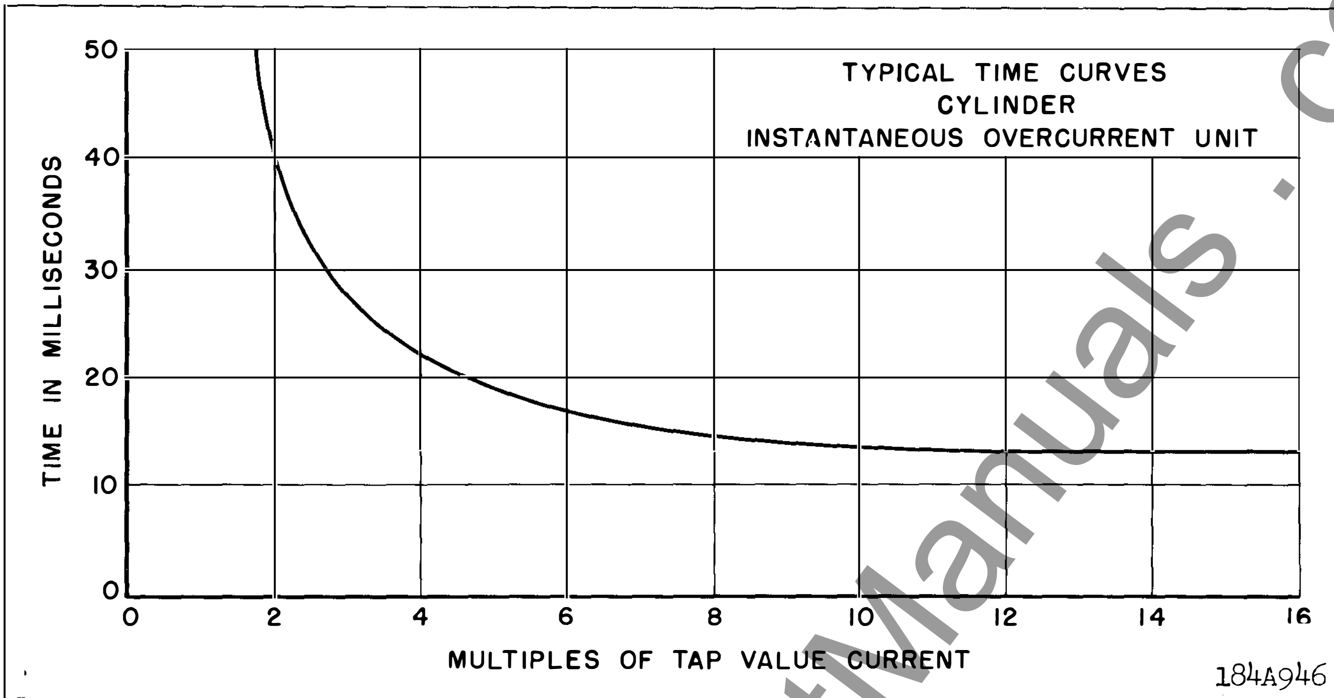


Fig. 4. Typical Time Curve of the Instantaneous Overcurrent Unit.

1165 ohms. Its operating time is approximately 1/2 cycle.

Cylinder Unit Contacts

The moving contact assembly has been factory adjusted for low contact bounce performance and should not be changed.

The set screw in each stationary contact has been shop adjusted for optimum follow and this adjustment should not be disturbed.

Directional Unit

The KRV relay is intended for phase fault protection and the directional unit has its maximum torque when the current leads the voltage by approximately 30°. The directional unit minimum pickup at its maximum torque angle is shown in Table 1.

TABLE 1.

RELAY RANGE	DIR. UNIT PICKUP
0.5 to 2 Amps.	1.2 Volts and 2 Amps.
1–4	1.2 Volts and 2 Amps.
2–8	1.2 Volts and 2 Amps.
4–16	1.2 Volts and 4 Amps.
10–40	1.2 Volts and 8 Amps.
20–80	1.2 Volts and 8 Amps.

The directional unit should be connected using the current in one-phase wire and the potential across the other two phase wires. This connection is commonly referred to as the 90° connection. When utilizing the 90° connection the maximum torque of the relay occurs when the fault current lags its 100% P.F. position by approximately 60°. See Fig. 7.

ENERGY REQUIREMENTS

BURDEN DATA OF OPERATING CURRENT CIRCUIT – 60 CYCLES

AMPERE RANGE	TAP	VA AT TAP VALUE††	P.F. ANGLE ϕ	VA AT 5 AMPS.††	P.F. ANGLE ϕ
.5-2	.5	0.40	36.8°	26.10	42.3°
	.75	0.45	35.3	16.70	36.9
	1.0	0.53	34.1	12.10	33.9
	1.25	0.62	33.1	9.43	33.1
	1.5	0.73	32.3	7.94	31.6
	2.0	0.96	32.1	6.06	31.1
1-4	1.0	0.53	31.1°	12.50	31.2°
	1.5	0.72	29.1	7.99	28.2
	2.0	0.96	28.7	6.09	27.8
	2.5	1.25	28.7	5.04	28.1
	3.0	1.63	29.6	4.57	28.9
	4.0	2.55	30.1	3.99	30.0
2-8	2	1.55	38.3°	9.54	37.6°
	3	2.26	35.5	6.25	34.8
	4	3.20	33.2	4.98	33.1
	5	4.39	32.8	4.40	32.7
	6	5.78	32.4	4.05	32.1
	8	9.31	31.8	3.62	32.4
4-16	4	2.05	42.8°	3.24	42.0°
	6	2.94	38.5	2.03	38.0
	8	4.09	35.7	1.59	35.7
	9	4.77	34.8	1.46	35.5
	12	7.30	33.3	1.24	34.3
	16	11.5	32.0	1.11	34.2
10-40	10	2.5	29°	.63	29°
	15	4.2	25	.47	25
	20	6.3	22	.40	22
	24	8.2	21	.35	21
	30	11	19	.31	19
	40	18	19	.28	19
20-80	20	10	32°	.60	32°
	30	17	28	.45	28
	40	25	24	.38	24
	48	32	23	.34	23
	60	45	22	.30	22
	80	70	21	.27	21

ϕ Degrees current lags voltage

†† Voltages taken with Rectox type voltmeter

RATINGS OF DIRECTIONAL AND OVERCURRENT UNITS

RANGE	OVERCURRENT UNIT CONTINUOUS RATING	OVERCURRENT UNIT ONE SECOND RATING	DIRECTIONAL UNIT CONTINUOUS RATING	DIRECTIONAL UNIT ONE SECOND RATING
0.5-2 Amps	5	100	8	200
1-4	8	140	8	200
2-8	8	140	8	200
4-16	10	200	10	230
10-40	10	200	10	280
20-80	10	200	10	280

† Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

DIRECTIONAL UNIT POLARIZING CIRCUIT BURDEN

The burden at 120V, 60 cycles, is 12.5 volt-amperes at 15 degrees. (current leading voltage).

SETTINGS

Instantaneous Overcurrent Unit (I)

The only setting required is the pickup current setting which is made by means of the connector screw located on the tap plate. By placing the connector screw in the desired tap, the relay will just close its contacts at the tap value current.

CAUTION Since the tap block connector screw carries operating current, be sure that the screw is turned tight.

In order to avoid opening the current transformer circuits when changing taps under load, connect the spare tap screw in the desired tap position before removing the other tap screw from the original tap position.

Directional Unit (D)

No setting is required.

Indicating Contactor Switch Unit (ICS)

No setting is required.

Auxiliary Switch (CS-1)

No setting required on the CS-1 unit except for the selection of the required 24, 48, 125 or 250 voltage on the tapped resistor. This connection can be made by referring to Fig. 6.

INSTALLATION

The relays should be mounted on switchboard panels or their equivalent in a location free from dirt, moisture, excessive vibration and heat. Mount the relay vertically by means of the two mounting studs for projection mounting or by means of the four mounting holes on the flange for the semi-flush mounting. Either of the studs or the mounting screws may be utilized for grounding the relay. The electrical connections may be made directly to the terminals by means of screws for steel panel mounting or to terminal studs furnished with the relay for thick panel mounting. The terminal studs may be easily removed or inserted by locking two nuts on the studs and then turning the proper nut with a wrench.

For detailed information on the PT Case, refer to I.L. 41-076.

The external connections of the directional overcurrent relays are shown in Fig. 7.

ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory. Upon receipt of the relay, no customer adjustments, other than those covered under "SETTINGS", should be required.

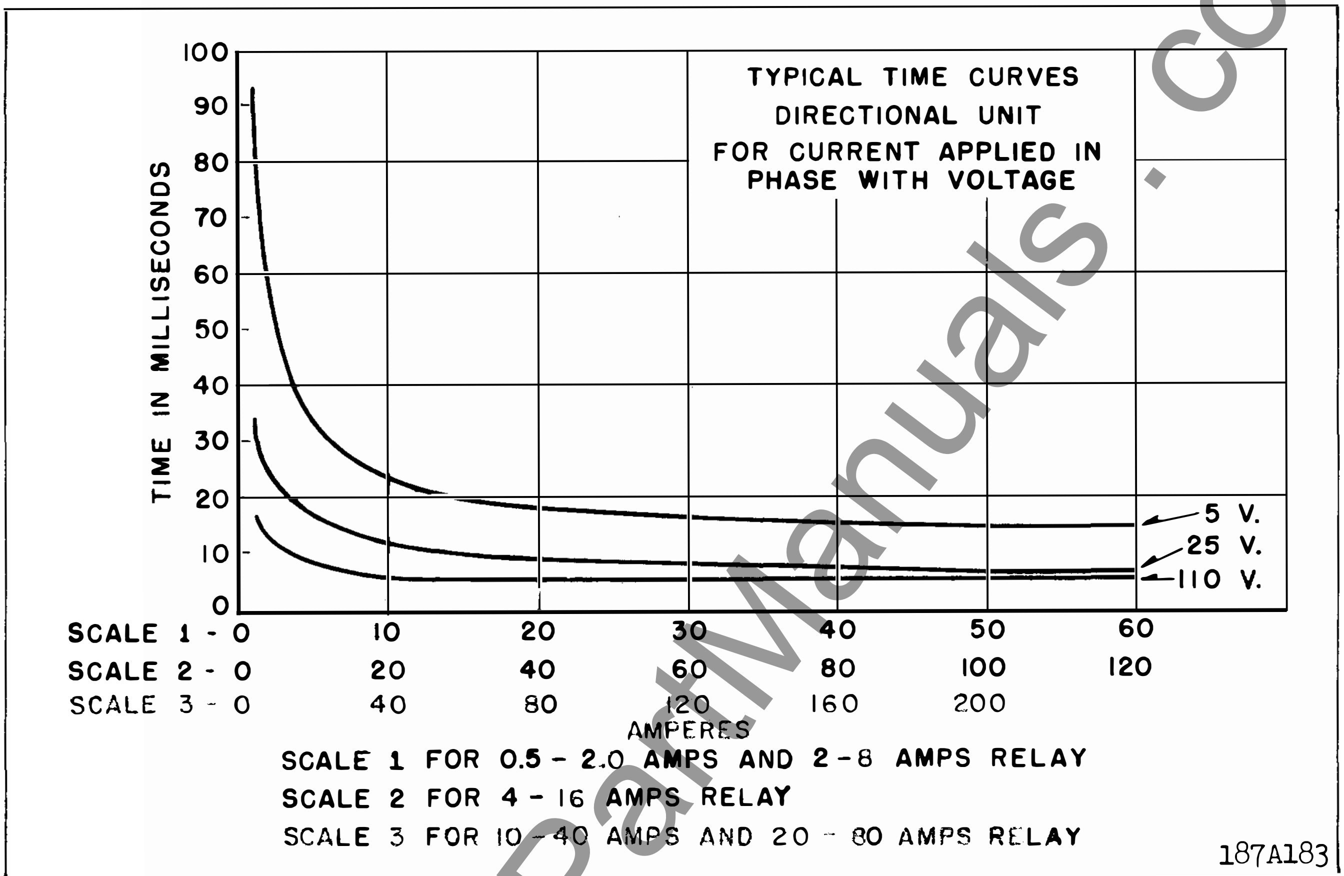


Fig. 5. Typical Time Curves of the Directional Unit.

Acceptance Check

The following check is recommended to insure that the relay is in proper working order;

Instantaneous Overcurrent Unit (I)

1. Contact Gap — The gap between the stationary and moving contacts with the relay in the de-energized position should be approximately .020".

2. Minimum Trip Current — The D contacts should be blocked closed when checking the pick-up of the overcurrent unit.

The pick-up of the overcurrent unit can be checked by inserting the tap screw in the desired tap hole and applying rated tap value current. The contact should close within ±5% of tap value current.

Directional Unit (D)

1. Contact Gap — The gap between the stationary contact and moving contact with the relay in the de-energized position should be approximately .020".

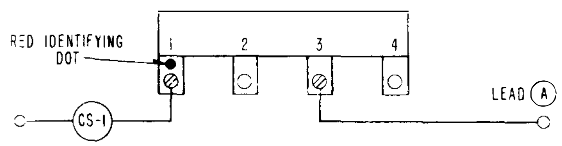
2. Sensitivity — The directional unit should pick up at its maximum torque angle (current leading the voltage by 30°) when energized with the value of current and voltage shown in Table 1.

3. Spurious Torque Adjustments — There should be no spurious closing torques when the operating circuits are energized per Table 2 with the polarizing circuit short circuited.

Indicating Contactor Switch (ICS)

Close the main relay contacts and pass sufficient d-c current through the trip circuit to close the contacts of the ICS. This value of current should be between 1 and 1.2 amperes. The indicator target should drop freely.

The contact gap should be approximately 5/64" between the bridging moving contact and the adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously. The third moving contact should make at approximately the same time.



POSITION LEAD (A)	RATED D-C VOLTAGE	RESISTOR RESISTANCE
1	24	0
2	48	300
3	125	2700
4	250	6500

NOTE RELAYS ARE SHIPPED ON THE 125 VOLT TAP

Fig. 6. Selection of Proper Voltage Tap for Auxiliary Switch (CS-1) Operation.

ROUTINE MAINTENANCE

All relays should be inspected periodically and the operation should be checked at least once every year or at such other time intervals as may be dictated by experience to be suitable to the particular application.

All contacts should be periodically cleaned. A contact burnisher S#182A836H01 is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact.

Calibration

Use the following procedure for calibrating the relay if the relay has been taken apart for repairs or the adjustments have been disturbed. This procedure should not be used unless it is apparent that the relay is not in proper working order. (See "Acceptance Check").

Instantaneous Overcurrent Unit (I)

1. The upper pin bearing should be screwed down until there is approximately .025" clearance between it and the top of shaft bearing. The upper pin bearing should then be securely locked in position with the lock nut. The lower bearing position is fixed and cannot be adjusted.

2. The contact gap adjustment for the overcurrent unit is made with the moving contact in the reset position, i.e., against the right side of the bridge.

Move in the left-hand stationary contact until it just touches the moving contact then back off the stationary contact 2/3 of one turn for a gap of approximately .020". The clamp holding the stationary contact housing need not be loosened for the adjustment since the clamp utilizes a spring-type action in holding the stationary contact in position.

3. The sensitivity adjustment is made by varying the tension of the spiral spring attached to the moving element assembly. The spring is adjusted by placing a screwdriver of similar tool into one of the notches located on the periphery of the spring adjuster and rotating it. The spring adjuster is located on the underside of the bridge and is held in place by a spring type clamp that does not have to be loosened prior to making the necessary adjustments. Before applying current block close the contacts of the D unit.

Insert the tap screw in the minimum setting and adjust the spring such that the contacts will close as indicated by a neon lamp in the contact circuit when energized with the required current. The pickup of the overcurrent unit with the tap screw any other tap should be within ±5% of the tap value.

If adjustment of pick-up current in between tap settings is desired insert the tap screw in the next lowest tap setting and adjust the spring as described. It should be noted that this adjustment results in a slightly different time characteristic curve and burden.

Directional Unit (D)

The directional unit is the lower cylinder unit.

1. The upper bearing screw should be screwed down until there is approximately .025" clearance between it and the top of the shaft bearing. The upper pin bearing should then be securely locked in position with the lock nut.

2. Contact gap adjustment for the directional unit is made with the moving contact in the reset position, i.e., against the right side of the bridge.

Move in the left-hand stationary contact until it just touches the moving contact. Then back off the stationary contact 2/3 of one turn for a contact gap of 0.20". The clamp holding the stationary contact

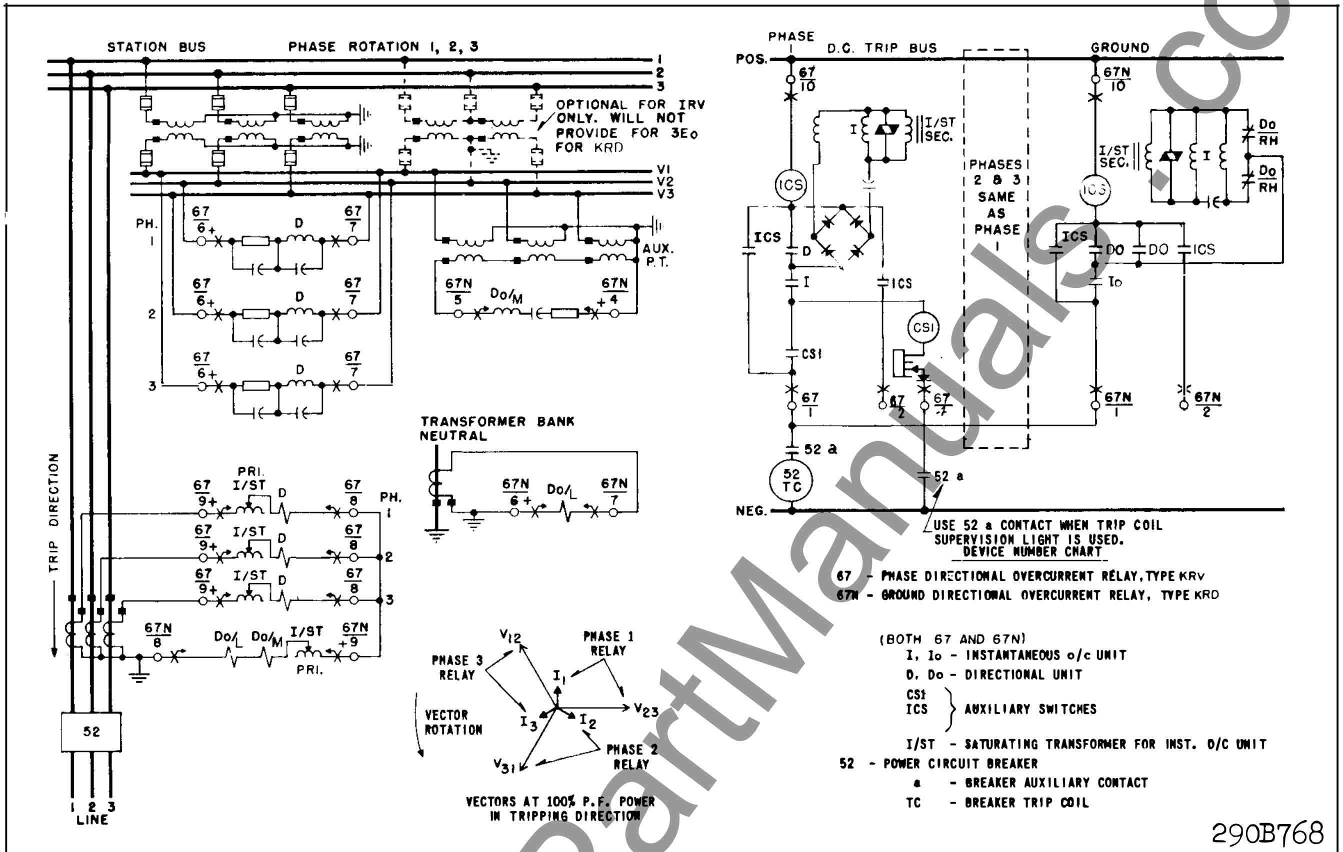


Fig. 7. External Schematic of the KRV Relay for Phase Protection and the KRD Relay for Ground Protection.

housing need not be loosened for the adjustment since the clamp utilizes a spring-type action in holding the stationary contact in position.

3. Insert tap screw of overcurrent unit in highest tap. The sensitivity adjustment is made by varying the tension of the spiral spring attached to the moving element assembly. The spring is adjusted by placing a screwdriver or similar tool into one of the notches located on the periphery of the spring adjuster and rotating it. The spring adjuster is located on the underside of the bridge and is held in place by a spring type clamp that does not have to be loosened prior to making the necessary adjustments.

The spring is to be adjusted such that the contact will close when the unit is energized at its maximum torque angle (current leading the voltage by 30°) with the value of current and voltage shown in Table I.

4. The magnetic plugs and core are used to reverse any unwanted spurious torques that may be present when the relay is energized on current alone.

The reversing of the spurious torques is accomplished by using the adjusting plugs and core in the following manner:

a. Apply 120 volts ac to terminals 6 and 7; relay should remain open. If contacts are closed, adjust the core until contacts stay open.

b. Insert tap screw in the highest value of the cylinder overcurrent unit.

c. Short circuit the voltage terminals (6 and 7).

d. Apply current as per Table II, adjusting only the plugs for spurious torque.

Auxiliary Switch (CS-1)

Adjust the stationary core of the switch for a clearance between the stationary core and the moving core when the switch is picked up. This can be done by turning the relay upside-down. Then screw up the core screw until the moving core starts rotating. Now back off the core screw until the moving core stops rotating. This indicates the points when the play in the assembly is taken up, and where the moving core just separates from the stationary core screw. Back off the core screw approximately one turn and lock in place. This prevents the moving core from striking and sticking to the stationary core because of residual magnetism. Adjust the contact clearance for 3/64" by means of the two small nuts on either side of the Micarta disc.

Connect lead (A) to proper terminal per Fig. 6. Block directional unit (D) and I contacts close and energize trip circuit with rated voltage. Contacts of auxiliary switch (CS-1) should make as indicated by a neon lamp in the contact circuit.

Indicating Contactor Switch (ICS)

Adjust the contact gap for approximately 5/64" (−1/64", +0).

Close the main relay contacts and check to see that the relay picks up and the target drops between 1 and 1.2 amperes d-c.

Bridge Rectifier and Blocking Diode

These diodes are silicon diodes type IN1225. If it is suspected that one or more are defective they can be checked for reverse leadage by applying 80% or less of rated diode voltage (700 VDC). The leakage current should be less than 0.5 MA. Voltage should be increased gradually.

If any of the diodes are open circuited, then either the CS1 switch or the I unit will become inoperative.

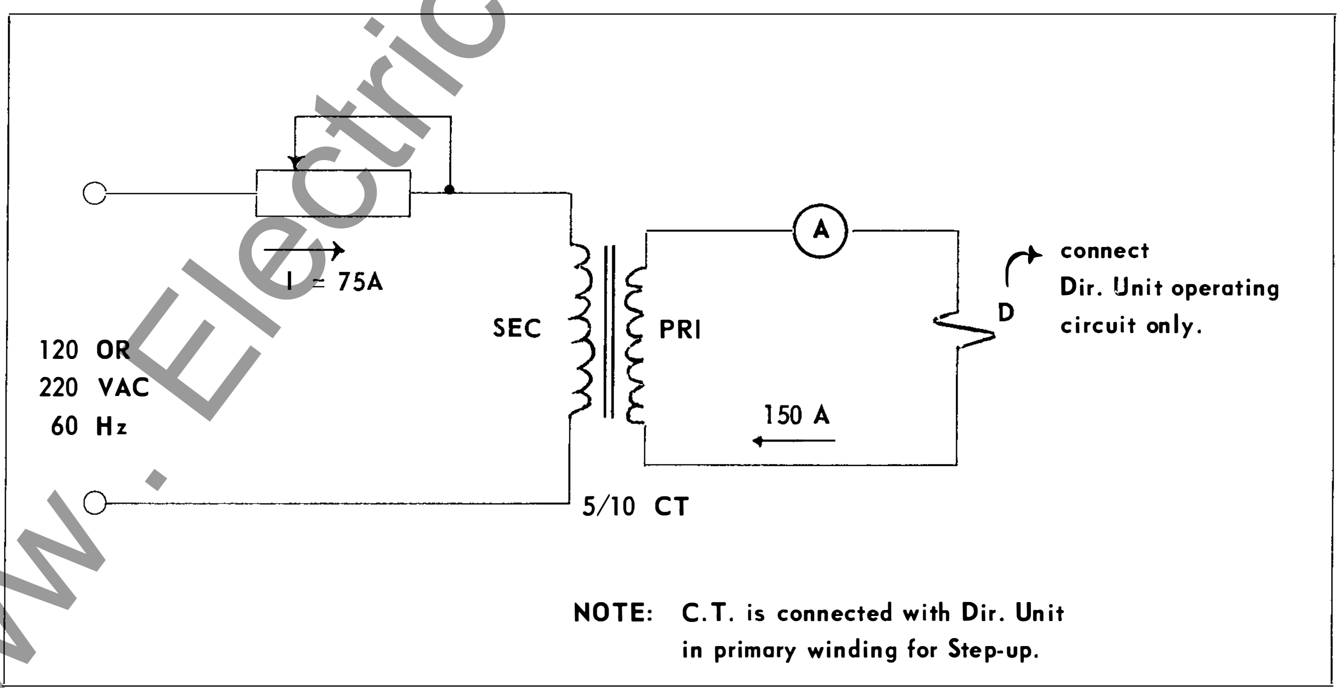
TABLE II

RELAY	CURRENT	* ADJUST	ADJUSTMENT	† CHECK POINTS
15 – 2 1 – 4 2 – 8	50 amps	Magnetic Plugs	If spurious torque is in contact closing dir. (left front) view, screw our r. mag. plug until dir. of spurious torque is reversed. If spurious torque is in contact opening dir., screw out left plug until torque is reversed. Then screw in for slight opening torque.	80, 50 and 20 Amps.
4 – 16	100			
10 – 40 20 – 80	150 △			120, 75 and 30 Amps.

* Plugs should be fully in prior to core adjustment.

† Slight re-adjustment may be necessary of core or plugs, if contact closes at these check points.

△ 150 Amps. may be obtained by using a 10/5 CT as shown below.



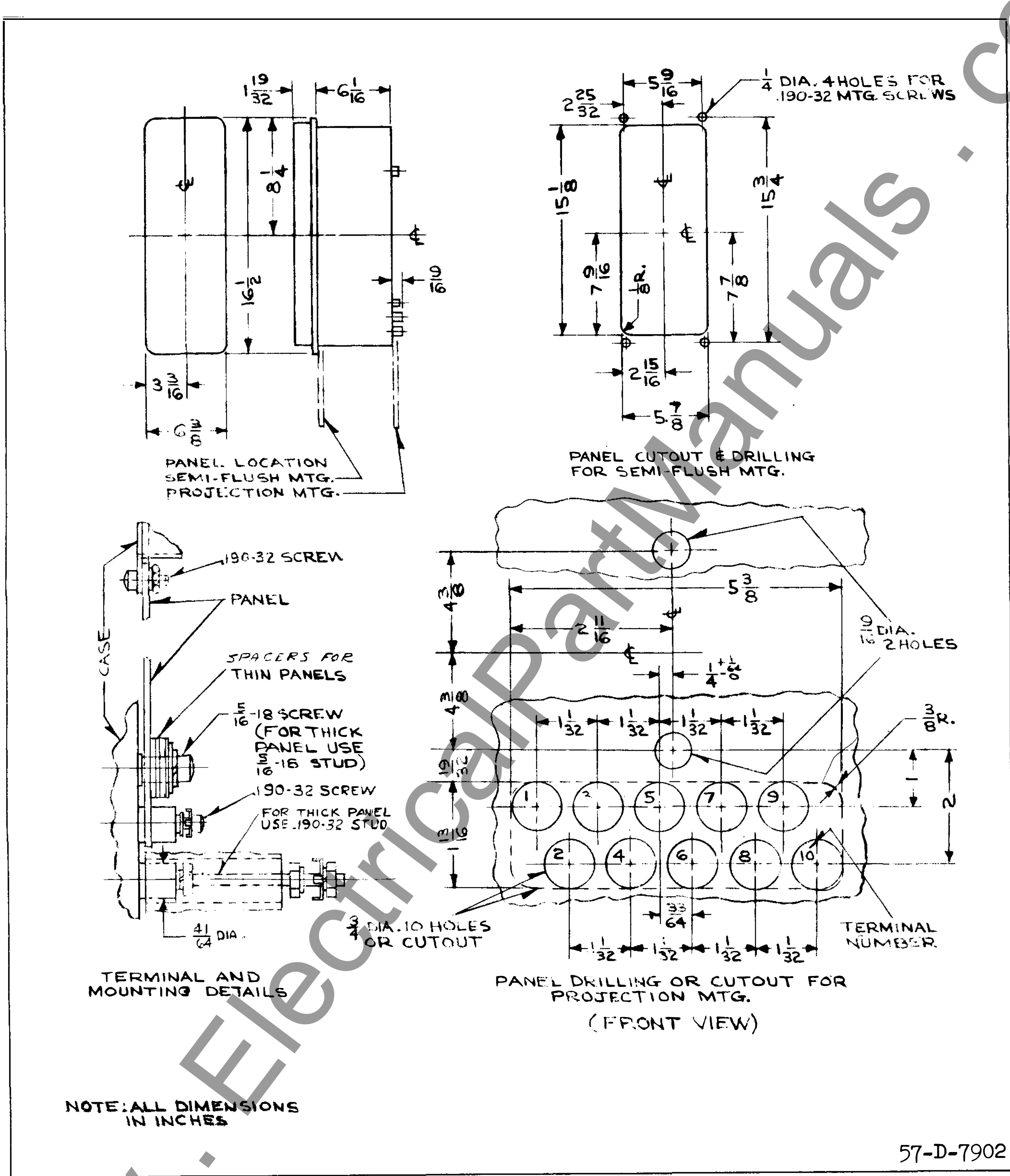


Fig. 8. Outline and Drilling Plan for the Type KRV Relay in the Type FT31 Case.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE KRV DIRECTIONAL OVERCURRENT RELAY

FOR PHASE PROTECTION

CAUTION Before putting relays into service, remove all blocking which may have been inserted for the purpose of securing the parts during shipment, make sure that all moving parts operate freely, inspect the contacts to see that they are clean and close properly, and operate the relay to check the settings and electrical connections.

APPLICATION

These relays are high speed phase directional overcurrent relays which are used for the protection of transmission lines and feeder circuits.

CONSTRUCTION AND OPERATION

The Type KRV relay consists of a directional unit (D), an auxiliary switch (CS-1), an instantaneous unit (I), an instantaneous overcurrent unit transformer, and an indicating contactor switch (ICS). The principle component parts of the relay and their location are shown in Figs. 1 and 2.

Directional Unit (D)

The directional unit is a product induction cylinder type unit operating on the interaction between the polarizing circuit flux and the operating circuit flux.

Mechanically, the directional unit is composed of four basic components: A die-cast aluminum frame, an electromagnet, a moving element assembly, and a molded bridge.

The frame serves as the mounting structure for the magnetic core. The magnetic core which houses the lower pin bearing is secured to the frame by a spring and snap ring. This is an adjustable core which has a .025 inch flat on one side and is held in its adjusted position by the clamping action of two compressed springs. The bearing can be replaced, if necessary, without having to remove the magnetic core from the frame.

The electromagnet has two series-connected polarizing coils mounted diametrically opposite one another, two series-connected operating coils mounted diametrically opposite one another; two magnetic adjusting plugs; upper and lower adjusting plug clips, and two locating pins. The locating pins are used to accurately position the lower pin bearing, which is mounted on the frame, with respect to the upper pin bearing, which is threaded into the bridge. The electromagnet is secured to the frame by four mounting screws.

The moving element assembly consists of a spiral spring, contact carrying member, and an aluminum cylinder assembled to a molded hub which holds the shaft. The shaft has removable top and bottom jewel bearings. The shaft rides between the bottom pin bearing and the upper pin bearing with the cylinder rotating in an air gap formed by the electromagnet and the magnetic core.

The bridge is secured to the electromagnet and frame by two mounting screws. In addition to holding the upper pin bearing, the bridge is used for mounting the adjustable stationary contact housing. The stationary contact housing is held in position by a spring type clamp. The spring adjuster is located on the underside of the bridge and is attached to the moving contact arm by a spiral spring. The spring adjuster is also held in place by a spring type clamp.

With the contacts closed, the electrical connection is made through the stationary contact housing clamp, to the moving contact, through the spiral spring out to the spring adjuster clamp.

Instantaneous Overcurrent Unit (I)

The instantaneous overcurrent unit is similar in construction to the directional unit. The time phase relationship of the two air gap fluxes necessary for the development of torque is achieved by means of a capacitor connected in series with one pair of pole windings.

SUPERSEDES I.L. 41-137.2A
*Denotes change from superseded issue.

EFFECTIVE JANUARY 1964

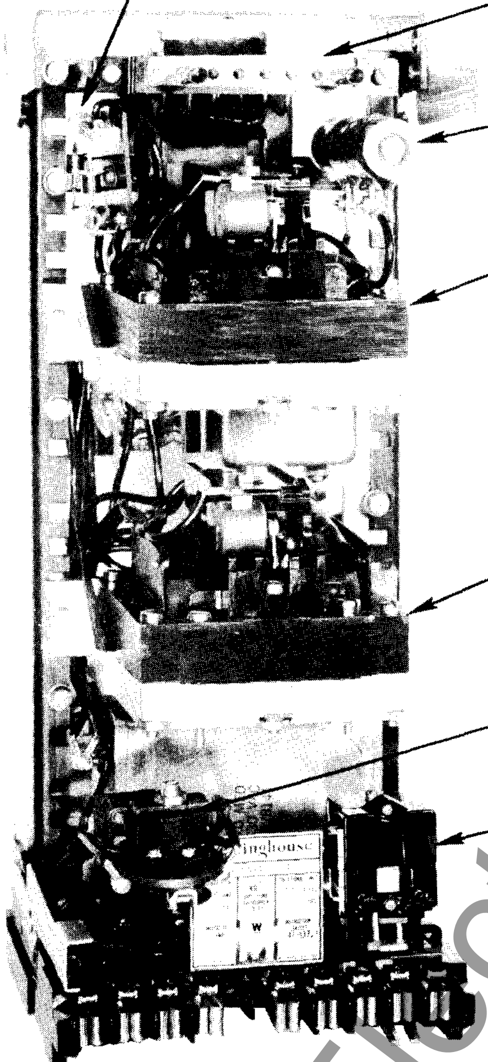


Fig. 1. Type KRV Relay Without Case (Front View)

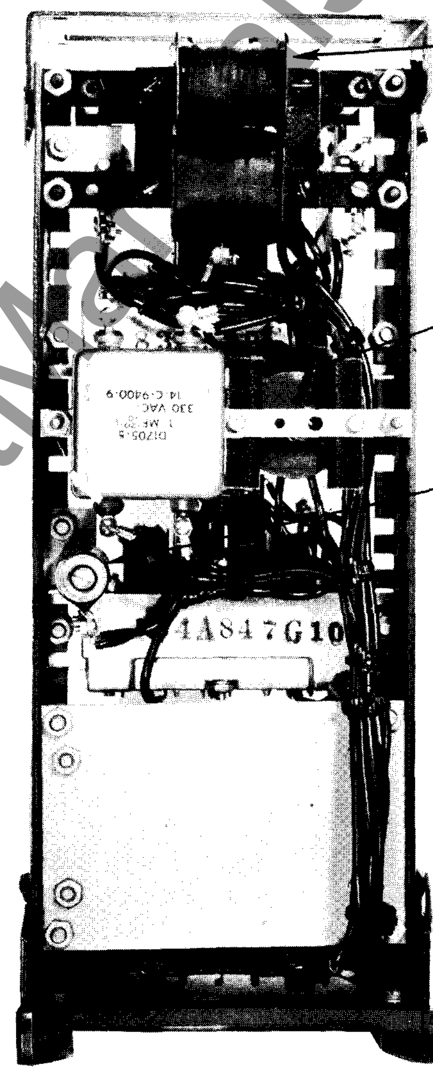


Fig. 2. Type KRV Relay Without Case (Rear View)

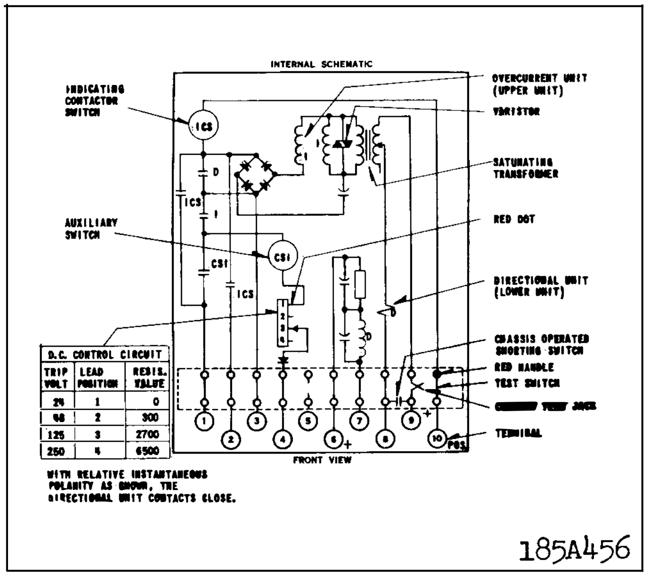


Fig. 3. Internal Schematic of the Type KRV Relay in the Type FT31 Case.

Instantaneous Overcurrent Unit Transformer

This transformer is of the saturating type for limiting the energy to the instantaneous overcurrent unit at higher values of fault current and to reduce C.T. burden. The primary winding is tapped and these taps are brought out to a tap block for ease in changing the pick-up of the instantaneous overcurrent unit. The use of a tapped transformer provides approximately the same energy level at a given multiple of pick-up current for any tap setting, resulting in one time curve throughout the range of the relay.

Across the secondary is connected a non-linear resistor known as a varistor. The effect of the varistor is to reduce the voltage peaks applied to the overcurrent unit and phase shifting capacitor.

Auxiliary Switch (CS-1)

The auxiliary switch is a small solenoid type d.c. switch. A cylindrical plunger, with a silver disc mounted on its lower end, moves in the core of the solenoid. As the plunger travels upward, the disc bridges the silver stationary contacts. A tapped resistor is used to enable one to use the contactor switch on a 24, 48, 125 or 250 volt d.c. system connected per Fig. 6. The operation of the CS-1 switch is controlled by the directional contact (D) and the I contact. It's function is to insure coordination between the directional contact (D) and the I contact to prevent tripping on reversed faults (where the directional contact was closed on load).

Indicating Contactor Switch (ICS)

The d-c indicating contactor switch is a small clapper type device. A magnetic armature, to which leaf-spring mounted contacts are attached, is attracted to the magnetic core upon energization of the switch. When the switch closes, the moving contacts bridge two stationary contacts, completing the trip circuit. Also during this operation two fingers on the armature deflect a spring located on the front of the switch, which allows the operation indicator target to drop.

The front spring, in addition to holding the target, provides restraint for the armature and thus controls the pick-up value of the switch.

CHARACTERISTICS

The relays are available in the following current ranges:

Instantaneous Overcurrent Unit (I)

Range	Taps					
0.5-2 Amps	0.5	0.75	1.0	1.25	1.5	2
1-4	1.0	1.5	2.0	2.5	3.0	4.0
2-8	2	3	4	5	6	8
4-16	4	6	8	9	12	16
10-40	10	15	20	24	30	40
* 20-80	20	30	40	48	60	80

The tap value is the minimum current required to just close the relay contacts.

The time vs. current characteristics for the instantaneous overcurrent unit is shown in Fig. 4.

The time vs. current characteristics for the directional unit is shown in Fig. 5.

Trip Circuit

The relay contacts will safely close 30 amperes at 250 volts d.c. and the seal-in contacts of the indicating contactor switch will safely carry this current long enough to trip a circuit breaker.

Trip Circuit Constants

The indicating contactor switch has a pickup of approximately 1 ampere. Its d-c resistance is 0.1 ohms.

Auxiliary Switch (CS-1)

The auxiliary switch has a d-c resistance of

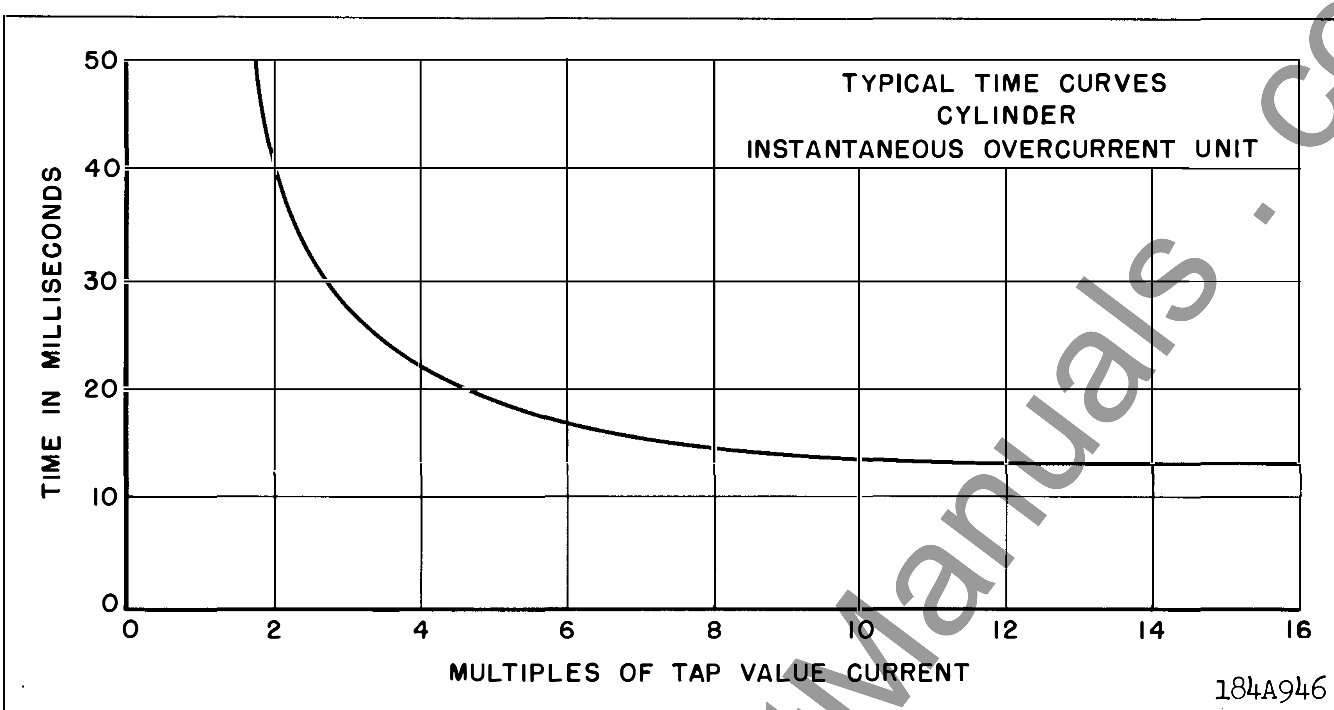


Fig. 4. Typical Time Curve of the Instantaneous Overcurrent Unit.

1165 ohms. Its operating time is approximately 1/2 cycle.

Cylinder Unit Contacts

The moving contact assembly has been factory adjusted for low contact bounce performance and should not be changed.

The set screw in each stationary contact has been shop adjusted for optimum follow and this adjustment should not be disturbed.

Directional Unit

The KRV relay is intended for phase fault protection and the directional unit has its maximum torque when the current leads the voltage by approximately 30°. The directional unit minimum pickup at its maximum torque angle is shown in Table 1.

TABLE 1.

RELAY RANGE	DIR. UNIT PICKUP
0.5 to 2 Amps.	1.2 Volts and 2 Amps.
1–4	1.2 Volts and 2 Amps.
2–8	1.2 Volts and 2 Amps.
4–16	1.2 Volts and 4 Amps.
10–40	1.2 Volts and 8 Amps.
20–80	1.2 Volts and 8 Amps.

The directional unit should be connected using the current in one-phase wire and the potential across the other two phase wires. This connection is commonly referred to as the 90° connection. When utilizing the 90° connection the maximum torque of the relay occurs when the fault current lags its 100% P.F. position by approximately 60°. See Fig. 7.

ENERGY REQUIREMENTS

BURDEN DATA OF OPERATING CURRENT CIRCUIT – 60 CYCLES

AMPERE RANGE	TAP	VA AT TAP VALUE††	P.F. ANGLE φ	VA AT 5 AMPS.††	P.F. ANGLE φ
.5-2	.5	0.40	36.8°	26.10	42.3°
	.75	0.45	35.3	16.70	36.9
	1.0	0.53	34.1	12.10	33.9
	1.25	0.62	33.1	9.43	33.1
	1.5	0.73	32.3	7.94	31.6
	2.0	0.96	32.1	6.06	31.1
1-4	1.0	0.53	31.1°	12.50	31.2°
	1.5	0.72	29.1	7.99	28.2
	2.0	0.96	28.7	6.09	27.8
	2.5	1.25	28.7	5.04	28.1
	3.0	1.63	29.6	4.57	28.9
	4.0	2.55	30.1	3.99	30.0
2-8	2	1.55	38.3°	9.54	37.6°
	3	2.26	35.5	6.25	34.8
	4	3.20	33.2	4.98	33.1
	5	4.39	32.8	4.40	32.7
	6	5.78	32.4	4.05	32.1
	8	9.31	31.8	3.62	32.4
4-16	4	2.05	42.8°	3.24	42.0°
	6	2.94	38.5	2.03	38.0
	8	4.09	35.7	1.59	35.7
	9	4.77	34.8	1.46	35.5
	12	7.30	33.3	1.24	34.3
	16	11.5	32.0	1.11	34.2
10-40	10	2.5	29°	.63	29°
	15	4.2	25	.47	25
	20	6.3	22	.40	22
	24	8.2	21	.35	21
	30	11	19	.31	19
	40	18	19	.28	19
20-80	20	10	32°	.60	32°
	30	17	28	.45	28
	40	25	24	.38	24
	48	32	23	.34	23
	60	45	22	.30	22
	80	70	21	.27	21

φ Degrees current lags voltage

†† Voltages taken with Rectox type voltmeter

RATINGS OF DIRECTIONAL AND OVERCURRENT UNITS

RANGE	OVERCURRENT UNIT CONTINUOUS RATING	OVERCURRENT UNIT ONE SECOND RATING	DIRECTIONAL UNIT CONTINUOUS RATING	DIRECTIONAL UNIT ONE SECOND RATING
0.5-2 Amps	5	100	8	200
1-4	8	140	8	200
2-8	8	140	8	200
4-16	10	200	10	230
10-40	10	200	10	280
20-80	10	200	10	280

† Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

DIRECTIONAL UNIT POLARIZING CIRCUIT BURDEN

The burden at 120V, 60 cycles, is 12.5 volt-amperes at 15 degrees. (current leading voltage).

SETTINGS

Instantaneous Overcurrent Unit (I)

The only setting required is the pickup current setting which is made by means of the connector screw located on the tap plate. By placing the connector screw in the desired tap, the relay will just close its contacts at the tap value current.

CAUTION Since the tap block connector screw carries operating current, be sure that the screw is turned tight.

In order to avoid opening the current transformer circuits when changing taps under load, connect the spare tap screw in the desired tap position before removing the other tap screw from the original tap position.

Directional Unit (D)

No setting is required.

Indicating Contactor Switch Unit (ICS)

No setting is required.

Auxiliary Switch (CS-1)

No setting required on the CS-1 unit except for the selection of the required 24, 48, 125 or 250 voltage on the tapped resistor. This connection can be made by referring to Fig. 6.

INSTALLATION

The relays should be mounted on switchboard panels or their equivalent in a location free from dirt, moisture, excessive vibration and heat. Mount the relay vertically by means of the two mounting studs for projection mounting or by means of the four mounting holes on the flange for the semi-flush mounting. Either of the studs or the mounting screws may be utilized for grounding the relay. The electrical connections may be made directly to the terminals by means of screws for steel panel mounting or to terminal studs furnished with the relay for thick panel mounting. The terminal studs may be easily removed or inserted by locking two nuts on the studs and then turning the proper nut with a wrench.

* For detailed information on the PT Case, refer to I.L. 41-076.

The external connections of the directional overcurrent relays are shown in Fig. 7.

ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory. Upon receipt of the relay, no customer adjustments, other than those covered under "SETTINGS", should be required.

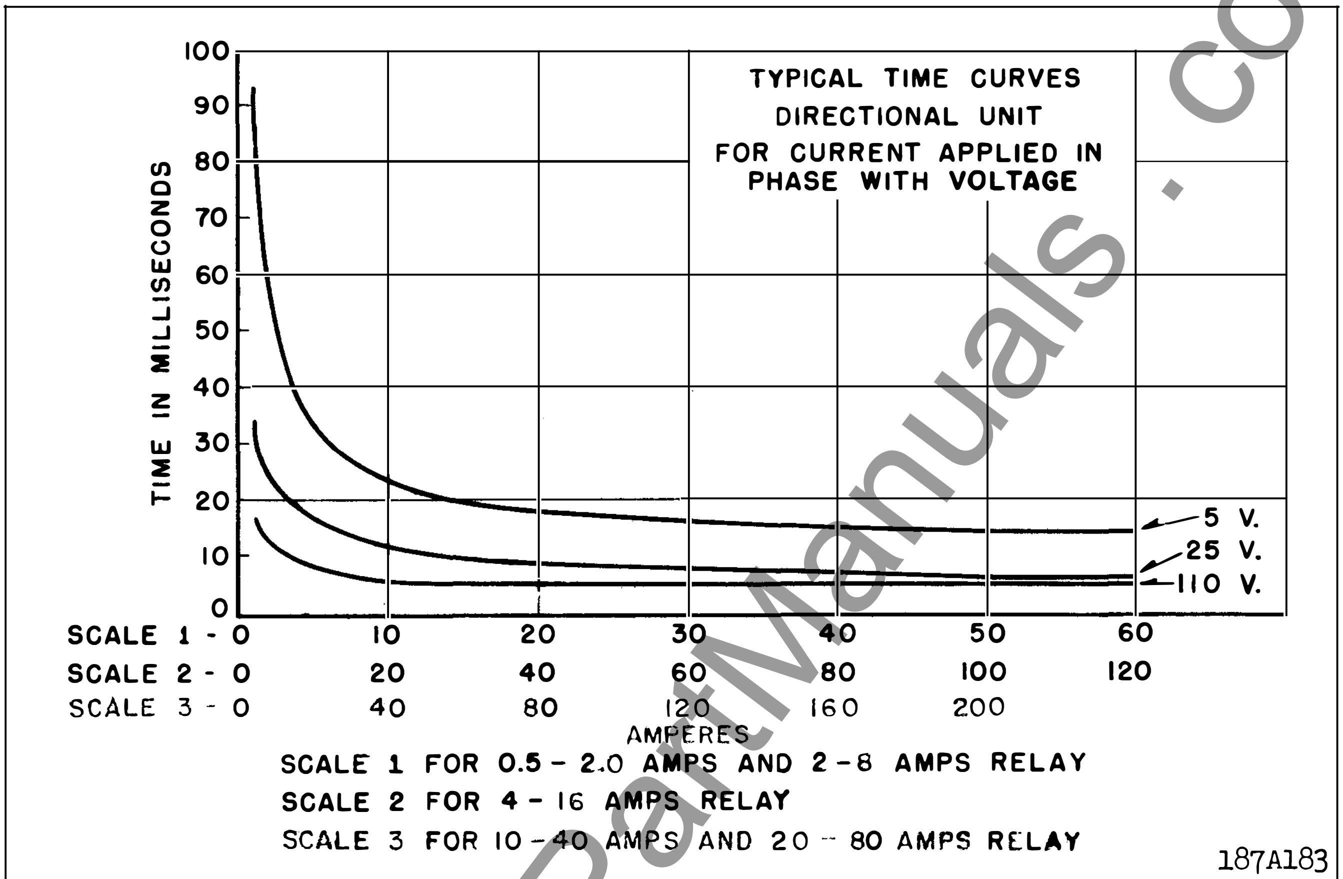


Fig. 5. Typical Time Curves of the Directional Unit.

Acceptance Check

The following check is recommended to insure that the relay is in proper working order;

Instantaneous Overcurrent Unit (I)

1. Contact Gap – The gap between the stationary and moving contacts with the relay in the de-energized position should be approximately .020".

* 2. Minimum Trip Current – The D contacts should be blocked closed when checking the pick-up of the overcurrent unit.

The pick-up of the overcurrent unit can be checked by inserting the tap screw in the desired tap hole and applying rated tap value current. The contact should close within ±5% of tap value current.

Directional Unit (D)

1. Contact Gap – The gap between the stationary contact and moving contact with the relay in the de-energized position should be approximately .020".

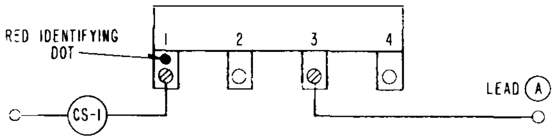
2. Sensitivity – The directional unit should pick up at its maximum torque angle (current leading the voltage by 30°) when energized with the value of current and voltage shown in Table 1.

3. Spurious Torque Adjustments – There should be no spurious closing torques when the operating circuits are energized per Table 2 with the polarizing circuit short circuited.

Indicating Contactor Switch (ICS)

Close the main relay contacts and pass sufficient d-c current through the trip circuit to close the contacts of the ICS. This value of current should be between 1 and 1.2 amperes. The indicator target should drop freely.

The contact gap should be approximately 5/64" between the bridging moving contact and the adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously. The third moving contact should make at approximately the same time.



POSITION LEAD (A)	RATED D-C VOLTAGE	RESISTOR RESISTANCE
1	24	0
2	48	300
3	125	2700
4	250	6500

NOTE RELAYS ARE SHIPPED ON THE 125 VOLT TAP

Fig. 6. Selection of Proper Voltage Tap for Auxiliary Switch (CS-1) Operation.

ROUTINE MAINTENANCE

All relays should be inspected periodically and the operation should be checked at least once every year or at such other time intervals as may be dictated by experience to be suitable to the particular application.

All contacts should be periodically cleaned. A contact burnisher S#182A836H01 is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact.

Calibration

Use the following procedure for calibrating the relay if the relay has been taken apart for repairs or the adjustments have been disturbed. This procedure should not be used unless it is apparent that the relay is not in proper working order. (See "Acceptance Check").

Instantaneous Overcurrent Unit (I)

1. The upper pin bearing should be screwed down until there is approximately .025'' clearance between it and the top of shaft bearing. The upper pin bearing should then be securely locked in position with the lock nut. The lower bearing position is fixed and cannot be adjusted.

2. The contact gap adjustment for the overcurrent unit is made with the moving contact in the reset position, i.e., against the right side of the bridge.

Move in the left-hand stationary contact until it just touches the moving contact then back off the stationary contact 2/3 of one turn for a gap of approximately .020''. The clamp holding the stationary contact housing need not be loosened for the adjustment since the clamp utilizes a spring-type action in holding the stationary contact in position.

3. The sensitivity adjustment is made by varying the tension of the spiral spring attached to the moving element assembly. The spring is adjusted by placing a screwdriver of similar tool into one of the notches located on the periphery of the spring adjuster and rotating it. The spring adjuster is located on the underside of the bridge and is held in place by a spring type clamp that does not have to be loosened prior to making the necessary adjustments. Before applying current block close the contacts of the D unit.

* Insert the tap screw in the minimum setting and adjust the spring such that the contacts will close as indicated by a neon lamp in the contact circuit when energized with the required current. The pickup of the overcurrent unit with the tap screw any other tap should be within ±5% of the tap value.

If adjustment of pick-up current in between tap settings is desired insert the tap screw in the next lowest tap setting and adjust the spring as described. It should be noted that this adjustment results in a slightly different time characteristic curve and burden.

Directional Unit (D)

The directional unit is the lower cylinder unit.

1. The upper bearing screw should be screwed down until there is approximately .025'' clearance between it and the top of the shaft bearing. The upper pin bearing should then be securely locked in position with the lock nut.

2. Contact gap adjustment for the directional unit is made with the moving contact in the reset position, i.e., against the right side of the bridge.

Move in the left-hand stationary contact until it just touches the moving contact. Then back off the stationary contact 2/3 of one turn for a contact gap of 0.20''. The clamp holding the stationary contact

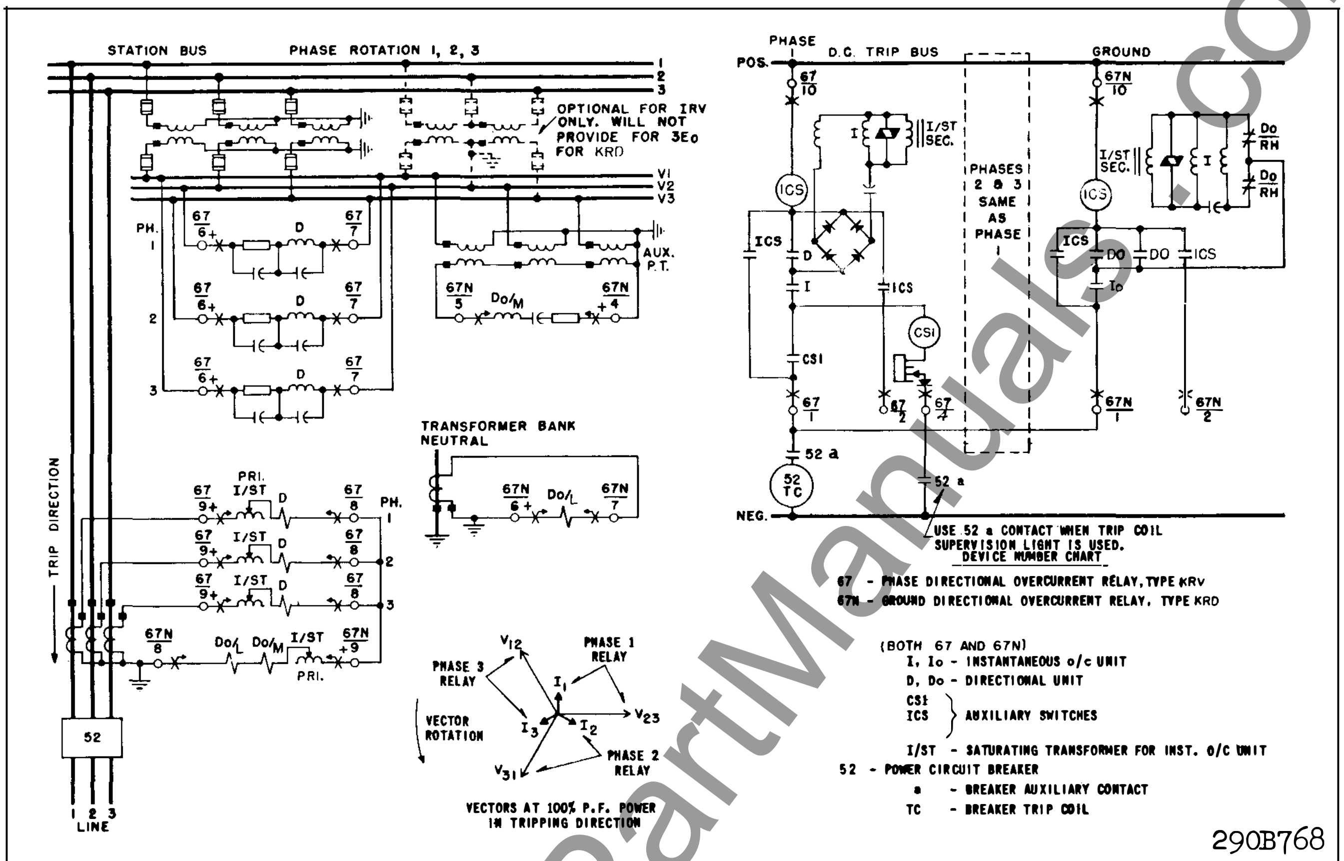


Fig. 7. External Schematic of the KRV Relay for Phase Protection and the KRD Relay for Ground Protection.

housing need not be loosened for the adjustment since the clamp utilizes a spring-type action in holding the stationary contact in position.

3. Insert tap screw of overcurrent unit in highest tap. The sensitivity adjustment is made by varying the tension of the spiral spring attached to the moving element assembly. The spring is adjusted by placing a screwdriver or similar tool into one of the notches located on the periphery of the spring adjuster and rotating it. The spring adjuster is located on the underside of the bridge and is held in place by a spring type clamp that does not have to be loosened prior to making the necessary adjustments.

The spring is to be adjusted such that the contact will close when the unit is energized at its maximum torque angle (current leading the voltage by 30°) with the value of current and voltage shown in Table 1.

4. The magnetic plugs and core are used to reverse any unwanted spurious torques that may be present when the relay is energized on current alone.

The reversing of the spurious torques is accomplished by using the adjusting plugs and core in the following manner:

Short circuit the voltage terminals and apply current to the operating circuit terminals as per Table 2.

Plug and core adjustment is then made per Table 2 such that the spurious torques are reversed. The plugs are held in position by upper and lower plug clips. These clips need not be disturbed in any manner when making the necessary adjustment. The core assembly is held in position by the clamping action of two compressed springs. This allows its position to be changed by inserting a non-magnetic tool into the slot on the bottom side of the unit.

The magnetic plug and core adjustment may be utilized to positively close the contacts on current alone. This may be desired on some installations in order to insure that the relay will always trip the breaker on zero potential.

Auxiliary Switch (CS-1)

Adjust the stationary core of the switch for a clearance between the stationary core and the moving core when the switch is picked up. This can be done by turning the relay upside-down. Then screw up the core screw until the moving core starts rotating. Now back off the core screw until the moving core stops rotating. This indicates the points when the play in the assembly is taken up, and where the moving core just separates from the stationary core screw. Back off the core screw approximately one turn and lock in place. This prevents the moving core from striking and sticking to the stationary core because of residual magnetism. Adjust the contact clearance for 3/64" by means of the two small nuts on either side of the Micarta disc.

Connect lead (A) to proper terminal per Fig. 6. Block directional unit (D) and I contacts close and energize trip circuit with rated voltage. Contacts of auxiliary switch (CS-1) should make as indicated by a neon lamp in the contact circuit.

Indicating Contactor Switch (ICS)

Adjust the contact gap for approximately 5/64" (−1/64", +0).

Close the main relay contacts and check to see that the relay picks up and the target drops between 1 and 1.2 amperes d-c.

Bridge Rectifier and Blocking Diode

These diodes are silicon diodes type IN1225. If it is suspected that one or more are defective they can be checked for reverse leadage by applying 80% or less of rated diode voltage (700 VDC). The leakage current should be less than 0.5 MA. Voltage should be increased gradually.

* If any of the diodes are open circuited, then either the CS1 switch or the I unit will become inoperative.

TABLE 2
DIRECTIONAL UNIT CALIBRATION †

Relay Rating	Current	Adjust	Adjustment	Check Points φ
.5-2 Amp 1-4 Amp 2-8 Amp	25 Amp	Core ††	Rotate core by means of adjuster located on bottom side of cylinder unit. Adjust core so that a slight contact opening torque is made.	15 & 5 Amps.
4-16 Amp	50 Amp			30 & 10 Amps
10-40 Amp 20-80 Amp	75 Amp			45 & 15 Amps
.5-2 Amp 1-4 Amp 2-8 Amp	50 Amp	Magnetic Plugs	If spurious torque is in the contact closing direction (left front view) screw out right magnetic plug until direction of spurious torque is reversed. If spurious torque is in the contact opening direction, screw out left plug until spurious torque is slight contact opening.	40, 25 & 10 Amps
4-16 Amp	100 Amp			80, 50 & 20 Amps
10-40 Amp 20-80 Amp	150 Amp			120, 75 & 30 Amps

† Short circuit the voltage polarizing circuit at the relay terminals before making the above adjustments.
†† Plugs should be at fully in position prior to adjustment of core.
φ There should be no closing torque at these points. Any tendency for the contact to pickup at these points may be reversed by slight readjustment of the core or plugs.

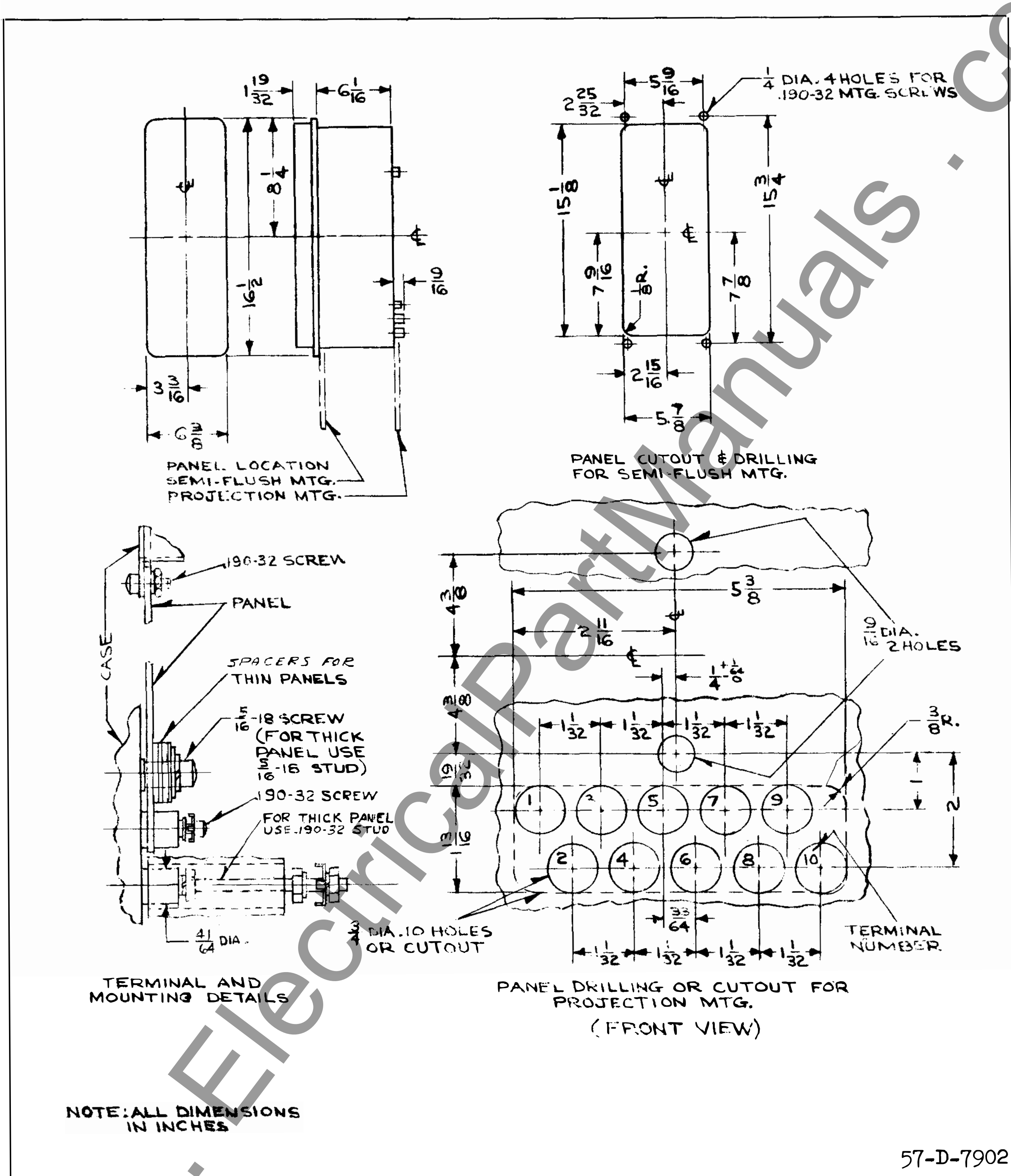


Fig. 8. Outline and Drilling Plan for the Type KRV Relay in the Type FT31 Case.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

DIRECTIONAL OVERCURRENT GROUND RELAY TYPES KRP KRC AND KRD

CAUTION Before putting relays into service, remove all blocking which may have been inserted for the purpose of securing the parts during shipment, make sure that all moving parts operate freely, inspect the contacts to see that they are clean and close properly, and operate the relay to check the settings and electrical connections.

APPLICATION

These relays are high speed ground directional overcurrent relays which are used for the protection of transmission lines and feeder circuits.

They are also used, without modification to provide directional ground fault protection in the KD carrier relaying scheme. Operation of the relays in connection with the carrier scheme is fully described in I.L. 41-911.

The type KRP relay is used where residual voltage is available for polarizing the directional unit. The type KRC is used where this residual voltage is not available and residual current must be used. The type KRD relay is a dual polarized relay which can be polarized from a potential source, from a local ground source or from both simultaneously.

CONSTRUCTION AND OPERATION

Directional Unit (D)

The directional unit is a product induction cylinder type unit operating on the interaction between the polarizing circuit flux and the operating circuit flux.

Mechanically, the directional unit is composed of four basic components: A die-cast aluminum frame, an electromagnet, a moving element assembly, and a molded bridge.

The frame serves as the mounting structure for the magnetic core. The magnetic core which houses the lower pin bearing is secured to the frame by a locking nut. The bearing can be replaced, if necessary, without having to remove the magnetic core from the frame.

The electromagnet has two series-connected polarizing coils mounted diametrically opposite one another; two series-connected operating coils mounted diametrically opposite one another; two magnetic adjusting plugs; upper and lower adjusting plug clips, and two locating pins. The locating pins are used to accurately position the lower pin bearing, which is threaded into the bridge. The electromagnet is secured to the frame by four mounting screws.

The moving element assembly consists of a spiral spring, contact carrying member, and an aluminum cylinder assembled to a molded hub which holds the shaft. The shaft has removable top and bottom jewel bearings. The shaft rides between the bottom pin bearing and the upper pin bearing with the cylinder rotating in an air gap formed by the electromagnet and the magnetic core.

The bridge is secured to the electromagnet and frame by two mounting screws. In addition to holding the upper pin bearing, the bridge is used for mounting the adjustable stationary contact housing. The stationary contact housing is held in position by a spring type clamp. The spring adjuster is located on the underside of the bridge and is attached to the moving contact arm by a spiral spring. The spring adjuster is also held in place by a spring type clamp.

With the contacts closed, the electrical connection is made through the stationary contact housing clamp, to the moving contact, through the spiral spring out to the spring adjuster clamp.

Overcurrent Unit (I)

The overcurrent unit is similar in construction to the directional unit. The time phase relationship of the two air gap fluxes necessary for the development of torque is achieved by means of a capacitor connected in series with one pair of pole windings.

The normally-closed contact of the directional unit is connected across one pair of pole windings of the overcurrent unit as shown in the internal schematics. This arrangement short-circuits the operating current around the pole windings; preventing the overcurrent unit from developing torque. If the direc-

SUPERSEDES I.L. 41-137G
*Denotes change from superseded issue.

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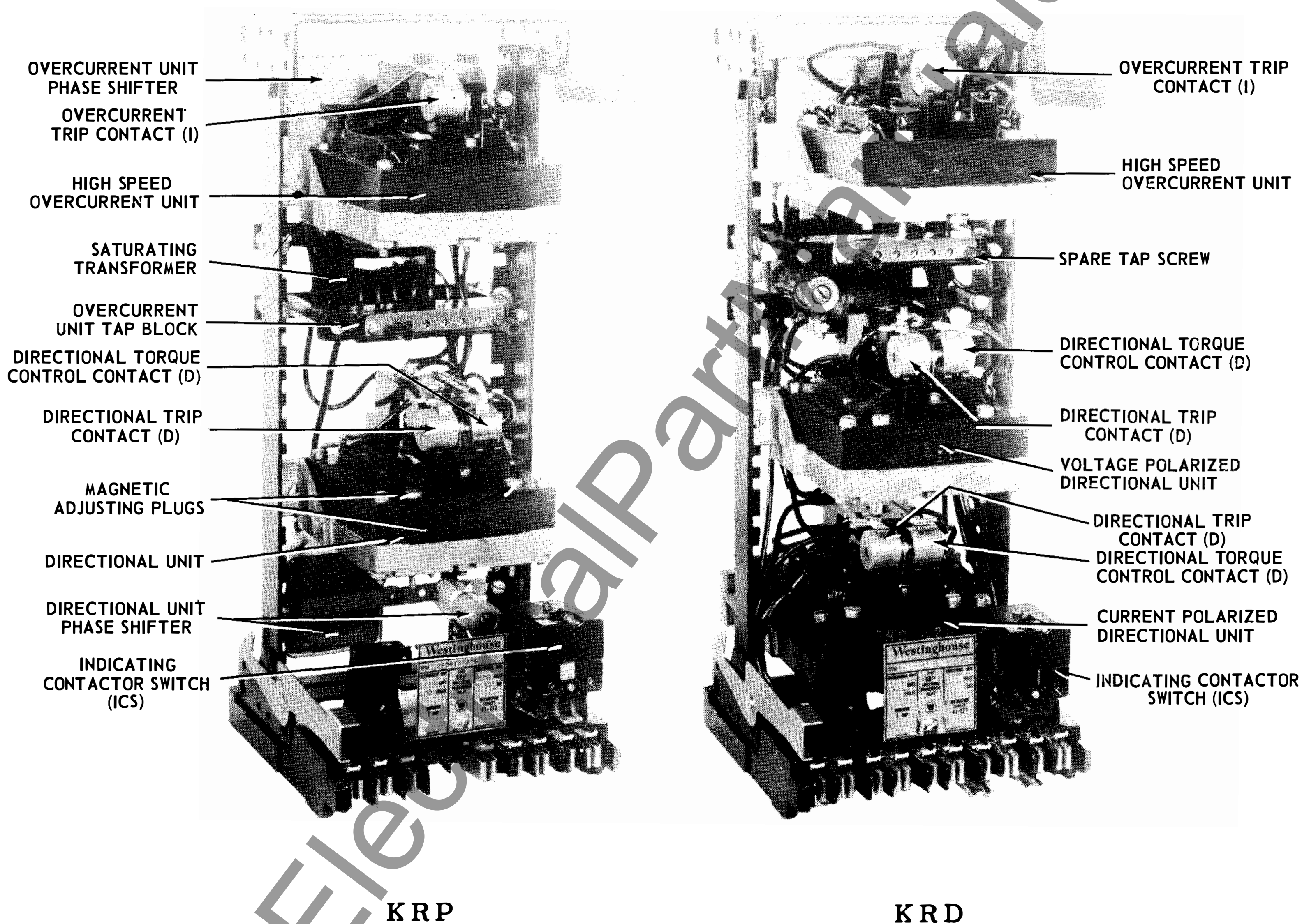


Fig. 1. Type KRP and KRD Relays without Case.

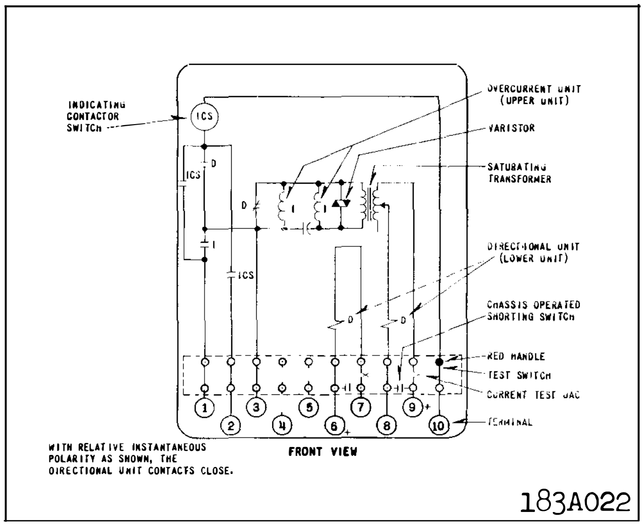


Fig. 2. Internal Schematic of the Type KRC Relay in the FT31 Case.

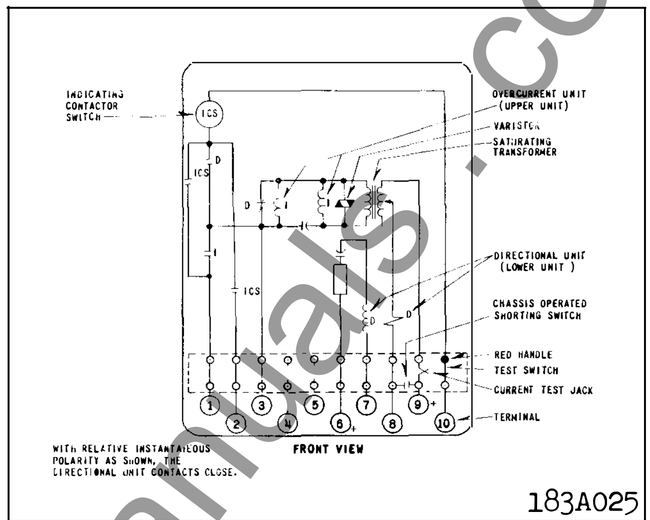


Fig. 3. Internal Schematic of the Type KRP Relay in the FT31 Case.

tional unit should pick up for a fault, this short-circuit is removed, allowing the overcurrent contact to commence closing almost simultaneously with the directional contact for high speed operation.

Overcurrent Unit Transformer

This transformer is of the saturating type for limiting the energy to the overcurrent unit at higher values of fault current and to reduce C.T. burden. The primary winding is tapped and these taps are brought out to a tap block for ease in changing the pick-up of the overcurrent unit. The use of a tapped transformer provides approximately the same energy level at a given multiple of pickup current for any tap setting, resulting in one time curve throughout the range of the relay.

Across the secondary is connected a non-linear resistor known as a varistor. The effect of the varistor is to reduce the voltage peaks applied to the overcurrent unit and phase shifting capacitor.

INDICATING CONTACTOR SWITCH UNIT (ICS)

The indicating contactor switch is a small d-c operated clapper type device. A magnetic armature, to which leaf-spring mounted contacts are attached, is attracted to the magnetic core upon energization of the switch. When the switch closes, the moving contacts bridge two stationary contacts, completing the trip circuit. Also during this operation two fingers on the armature deflect a spring located on the front of the switch, which allows the operation indicator target to drop. The target is reset from the outside of the case by a push rod located at the bottom of the cover.

The front spring, in addition to holding the target, provides restraint for the armature and thus controls the pickup value of the switch.

CHARACTERISTICS

The relays are available in the following current ranges:

Range	Taps					
0.5-2 Amps	0.5	0.75	1.0	1.25	1.5	2
1-4	1.0	1.5	2.0	2.5	3.0	4.0
2-8	2	3	4	5	6	8
4-16	4	6	8	9	12	16
10-40	10	15	20	24	30	40

The tap value is the minimum current required to just close the overcurrent relay contacts. For pick-up settings in between taps refer to the section under adjustments.

Type KRP Relay

The KRP relay is designed for potential polarization and has its maximum torque when the current lags the voltage by approximately 60 degrees. The shifting of the maximum torque angle is accomplished by the use of an internally mounted phase shifter as shown in the internal schematic.

The directional unit minimum pick-up is approximately 1 volt and 2 amperes at its maximum torque angle for the 0.5 to 2, 1 to 4, and 2 to 8 ampere range relays. For the 4 to 16 and 10 to 40 ampere

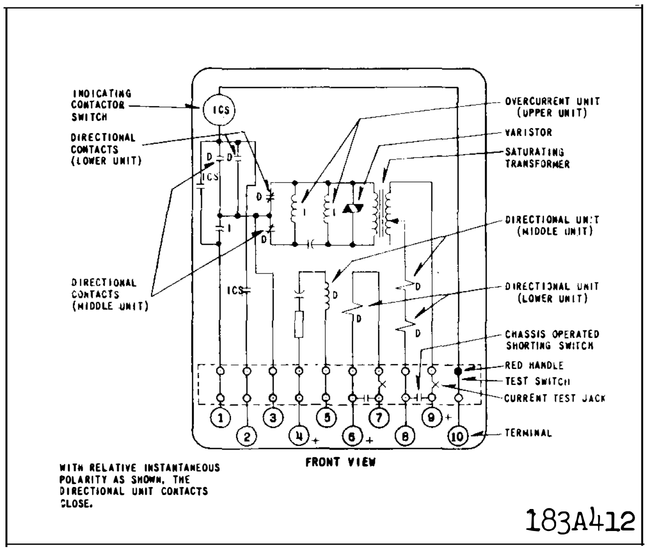


Fig. 4. Internal Schematic of the Type KRD Relay in the FT31 Case.

range, the minimum pick-up is 1 volt and 4 amperes.

Type KRC Relay

The KRC relay is designed for current polarization and has its maximum torque when the operating current leads the polarizing current by approximately 40°.

The directional unit minimum pick-up is 0.5 ampere in each winding at the maximum torque angle for the 0.5 to 2, 1 to 4, and 2 to 8 ampere range relays. For the 4 to 16 and 10 to 40 ampere range, the minimum pick-up is 1 ampere.

Type KRD Relay

The type KRD relay utilizes a directional unit similar to the KRC relay in conjunction with the directional unit and phase-shifting circuit of the KRP relay.

The current-polarized directional unit of the KRD relay operates on residual currents while the potential-polarized directional unit of the KRD relay operates on residual voltage and residual current.

For the 0.5 to 2, 1 to 4, and 2 to 8 ampere range relays, the minimum pick-up of the current polarized unit is 0.5 ampere in each winding at the maximum torque angle. The minimum pick-up for the voltage polarized unit is 1 volt and 2 amperes with the current lagging voltage by 60°.

For the 4 to 16 and the 10 to 40 ampere range relays, the minimum pick-up is 1 ampere for the current-polarized directional unit, and 1 volt and 4 amperes for the voltage-polarized directional unit.

TIME CURVES

The time curves for the KRD relay are shown in Fig. 5 and 6. Fig. 5 consists of three curves which are:

1) Directional Unit opening times for current and voltage polarized.
2) Directional Unit closing time for current and voltage polarized.
3) Directional Unit closing time for 1 volt, voltage polarized.

Fig. 6 shows the instantaneous overcurrent unit closing time.

The voltage polarized curve B begins to deviate from curve A for less than 5 volts.

Both the directional unit and the overcurrent unit must operate before the trip circuit can be completed. Hence, the unit which takes the longer time to operate determines when the breaker will be tripped. The overcurrent unit contacts cannot operate until the back contacts of directional unit open; therefore, the total time for overcurrent unit to operate is its closing time given in Fig. 6 plus the directional unit opening time given in Fig. 5. The total closing time for the directional unit is given in Fig. 5. The two examples below will serve to illustrate the use of the curves.

Example 1: Using the formulas and definition of symbols on Fig. 5, we have—

Let: Ipol = 2 amps.
Iop = 2.31
Tap Value (T) = 0.5 amp.
$\phi = 0^{\circ}$

For current polarized relay:

* $$MPP = \frac{Iop\ Ipol\ Cos\ \phi}{.25}$$

* $$MPP = \frac{(2.31)(2)}{.25} = 18.5$$

* Referring to Fig. 5 at multiples of product pickup of 18.5, the directional unit opening time is about 11 ms, and the closing time for this unit is 56 ms.

For overcurrent unit:

$$\text{Multiples of pickup} = \frac{Iop}{T} = \frac{2.31}{0.5} = 4.6$$

Entering the curve in Fig. 6 at multiples of pickup equal to 4.6, the closing time for the overcurrent is 16 ms. However, the total operating time for the overcurrent unit is 16 plus 10, which is the opening time of back contacts of the directional unit, or 26 ms total operating time for overcurrent unit. The total time for * directional unit is 56 ms; and, since this is the longest time, 51 ms is the total operating time of the relay.

Example 2:

Let: $I_{pol} = 20$ amps.
$I_{op} = 23.1$ amps.
T (tap) = 1 amp.
$\phi i = 0$

$$Mpp = \frac{I_{op}\, I_{pol} \cos \phi}{.25}$$

*

$$MPP = \frac{(20)\,(23.1) = 1850}{.25}$$

* Entering Fig. 5, the directional unit closing time is 12 ms, and the opening time of its back contacts is 1 ms. The total operating time for the directional unit is 12 ms.

For overcurrent unit:
Multiples of pickup $= \frac{I_{op}}{T} = \frac{23.1}{1} = 23.1$

* Referring to Fig. 6, the overcurrent unit contact closing time is about 10 ms. Therefore, the total operating time for this unit is 13 plus 1 or 14 ms. In this case the total operating time of relay is 14 ms.

Trip Circuit

The main contacts will safely close 30 amperes at 250 volts d-c and the seal-in contacts of the indicating contactor switch will safely carry this current long enough to trip a circuit breaker.

The indicating contactor switch has a pickup of approximately 1 ampere. Its d-c resistance is 0.1 ohms.

Cylinder Unit Contacts

The moving contact assembly has been factory adjusted for low contact bounce performance and should not be changed.

The set screw in each stationary contact has been shop adjusted for optimum follow and this adjustment should not be disturbed.

SETTINGS

Overcurrent Unit (I)

The only setting required is the pickup current setting which is made by means of the connector screw located on the tap plate. By placing the connector screw in the desired tap, the relay will just close its contacts at the tap value current.

For carrier relaying the carrier trip overcurrent unit located in the type KRP, KRC or KRD relay should be set on a higher tap than the carrier start overcurrent unit located in the type KA relay at the opposite end of the line.

CAUTION Since the tap block connector screw carries operating current, be sure that the screw is turned tight.

In order to avoid opening the current transformer circuits when changing taps under load, connect the spare tap screw in the desired tap position before removing the other tap screw from the original tap position.

Directional Unit (D)

No setting is required.

INSTALLATION

The relays should be mounted on switchboard panels or their equivalent in a location free from dirt, moisture, excessive vibration and heat. Mount the relay vertically by means of the two mounting studs for projection mounting or by means of the four mounting holes on the flange for the semi-flush mounting.

ENERGY REQUIREMENTS

BURDEN DATA OF OPERATING CURRENT CIRCUIT – 60 CYCLES

TYPE KRP RELAY

AMPERE RANGE	TAP	VA AT TAP VALUE π	P.F. ANGLE ϕ	VA AT 5 AMPS. π	P.F. ANGLE ϕ
.5-2	.5	0.40	36.8°	26.10	42.3°
	.75	0.45	35.3	16.70	36.9
	1.0	0.53	34.1	12.10	33.9
	1.25	0.62	33.1	9.43	33.1
	1.5	0.73	32.3	7.94	31.6
	2.0	0.96	32.1	6.06	31.1
1-4	1.0	0.53	31.1°	12.50	31.2°
	1.5	0.72	29.1	7.99	28.2
	2.0	0.96	28.7	6.09	27.8
	2.5	1.25	28.7	5.04	28.1
	3.0	1.63	29.6	4.57	28.9
	4.0	2.55	30.1	3.99	30.0
2-8	2	1.55	38.3°	9.54	37.6°
	3	2.26	35.5	6.25	34.8
	4	3.20	33.2	4.98	33.1
	5	4.39	32.8	4.40	32.7
	6	5.78	32.4	4.05	32.1
	8	9.31	31.8	3.62	32.4
4-16	4	2.05	42.8°	3.24	42.0°
	6	2.94	38.5	2.03	38.0
	8	4.09	35.7	1.59	35.7
	9	4.77	34.8	1.46	35.5
	12	7.30	33.3	1.24	34.3
	16	11.5	32.0	1.11	34.2
10-40	10	5.23	30.9°	1.33	30.8°
	15	10.5	30.3	1.15	31.3
	20	17.6	30.3	1.07	30.8
	24	24.1	29.4	1.05	29.9
	30	36.8	30.1	0.99	31.6
	40	64.9	28.9	0.97	31.9

ϕDegrees current lags voltage.
πVoltages taken with Rectox type voltmeter.

ENERGY REQUIREMENTS – 60 CYCLES

TYPE KRC RELAY

AMPERE RANGE	TAP	VA AT TAP VALUE π	P.F. ANGLE φ	VA AT 5 AMPS. π	P.F. ANGLE φ
.5-2	.5	0.42	39.5°	27.50	43.6°
	.75	0.49	37.9	17.60	39.5
	1.0	0.57	36.9	13.00	37.8
	1.25	0.68	36.0	10.50	35.9
	1.5	0.81	36.0	8.98	35.6
	2.0	1.10	36.4	6.94	35.4
1-4	1.0	0.57	37.1°	13.30	38.1°
	1.5	0.79	36.7	8.79	36.8
	2.0	1.10	37.1	6.84	36.8
	2.5	1.46	37.9	5.90	37.4
	3.0	1.92	38.4	5.34	38.1
	4.0	3.06	39.6	4.77	39.1
2-8	2	1.68	39.8°	10.50	38.8°
	3	2.58	37.3	7.03	36.5
	4	3.75	36.1	5.87	35.8
	5	5.19	35.8	5.17	35.7
	6	7.07	35.8	4.88	36.1
	8	11.30	35.7	4.51	36.8
4-16	4	2.17	42.2°	3.37	42.0°
	6	3.20	38.0	2.22	37.8
	8	4.64	35.5	1.80	36.0
	9	5.37	35.8	1.67	35.7
	12	8.52	34.8	1.46	35.0
	16	13.8	33.7	1.33	35.0
10-40	10	6.08	34.0°	1.52	33.9°
	15	12.2	32.6	1.34	34.1
	20	20.5	31.8	1.27	34.5
	24	28.7	31.3	1.24	34.5
	30	43.4	30.4	1.19	35.4
	40	78.3	28.5	1.16	35.6

φ Degrees current lags voltage.
π Voltages taken with Rectox type voltmeter.

ENERGY REQUIREMENTS – 60 CYCLES

TYPE KRD RELAY

AMPERE RANGE	TAP	VA AT TAP VALUE π	P.F. ANGLE ¢	VA AT 5 AMPS. π	P.F. ANGLE ¢
.5-2	.5	0.42	39.5°	28.30	47.0°
	.75	0.51	39.5	19.80	43.0
	1.0	0.63	39.5	14.50	41.0
	1.25	0.78	40.0	12.10	40.0
	1.5	0.97	40.0	10.60	40.0
	2.0	1.44	40.0	8.80	40.0
1-4	1.0	0.65	39.0°	15.20	40.0°
	1.5	1.01	39.5	11.00	40.0
	2.0	1.48	40.0	9.10	40.0
	2.5	2.10	40.5	8.25	40.5
	3.0	3.85	41.0	7.75	41.0
	4.0	4.56	41.5	7.25	41.5
2-8	2	2.01	46.0°	12.75	45.5°
	3	3.44	44.0	9.50	43.5
	4	5.36	42.5	8.40	42.5
	5	7.75	42.0	7.75	42.0
	6	10.71	42.0	7.45	42.0
	8	18.40	42.0	7.15	
44-16	4	2.86	40.0°	4.45	40.0°
	6	4.83	34.0	3.34	34.0
	8	7.58	32.0	2.90	31.0
	9	9.09	31.0	2.78	31.0
	12	14.70	30.0	2.58	30.0
	16	25.00	30.0	2.40	30.0
10-40	10	10.5	30.0°	2.60	30.0°
	15	22.0	29.5	2.40	29.5
	20	37.8	29.0	2.35	29.5
	24	55.2	29.0	2.30	29.5
	30	84.0	28.5	2.25	29.5
	40	149.0	28.0	2.24	29.5

¢ Degrees current lags voltage.
π Voltages taken with Rectox type voltmeter.

OVERCURRENT UNIT BURDEN DATA AT HIGH CURRENTS

TYPE KRD RELAY

AMPERE RANGE	1 - 4											
Tap Value Current	1				2				4			
Multiples of Tap Value Current	20	40	60	80	10	20	30	40	5	10	15	20
VA π	65	176	330	560	27	76.8	156	236	12.4	40	85.2	136
P.F. Angle ¢	41°	35°	27.2°	23.6°	35.6°	28.8°	23.8°	21.5°	24.3°	22.7°	19.9°	16.1°

ENERGY REQUIREMENTS – 60 CYCLES

DIRECTIONAL UNIT POLARIZING CIRCUIT BURDEN

RELAY TYPE	RATING	VOLT AMPERES Δ	POWER FACTOR ANGLE ¢
KRC	230 τ Amperes	1.45	8^{0} Lag
KRP	208 ττ Volts	11.2	28^{0} Lead
KRD Current Unit	230 τ Amperes	1.45	8^{0} Lag
KRD Voltage Unit	208 ττ Volts	11.2	28^{0} Lead

¢ Degrees current leads or lags voltage at 120 volts on voltage polarized units and 5 amperes on current polarized units.

Δ Burden of voltage polarized units taken at 120 volts. Burden of current polarized units taken at 5 amperes.

τ One second rating

ττ 30 second rating. The 10 second rating is 345 volts. The continuous rating is 120 volts.

Either of the studs or the mounting screws may be utilized for grounding the relay. The electrical connections may be made directly to the terminals by means of screws for steel panel mounting or to terminal studs furnished with the relay for thick panel mounting. The terminal studs may be easily removed or inserted by locking two nuts on the studs and then turning the proper nut with a wrench.
For detailed information, refer to I.L. 41-076.

The external a-c connections of the directional overcurrent relays are shown in Figs. 7, 8 and 9. If no voltage polarizing source is to be connected to the KRD relay, short-circuit the voltage polarizing circuit at the terminals of the relay.

ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory. Upon receipt of the relay, no customer adjustments, other than those covered under "SETTINGS", should be required.

Acceptance Check

The following check is recommended to insure that the relay is in proper working order;

Overcurrent Unit (I)

1. Contact Gap – The gap between the stationary and moving contacts with the relay in the de-energized position should be approximately .020".

2. Minimum Trip Current – The normally-closed contact of the directional unit should be blocked open when checking the pick-up of the overcurrent unit.

The pick-up of the overcurrent unit can be checked by inserting the tap screw in the desired tap hole and applying rated tap value current. The contact should close within ±5% of tap value current.

Directional Unit (D)

1. Contact Gap – The gap between the stationary contact and moving contact with the relay in the de-energized position should be approximately .020".

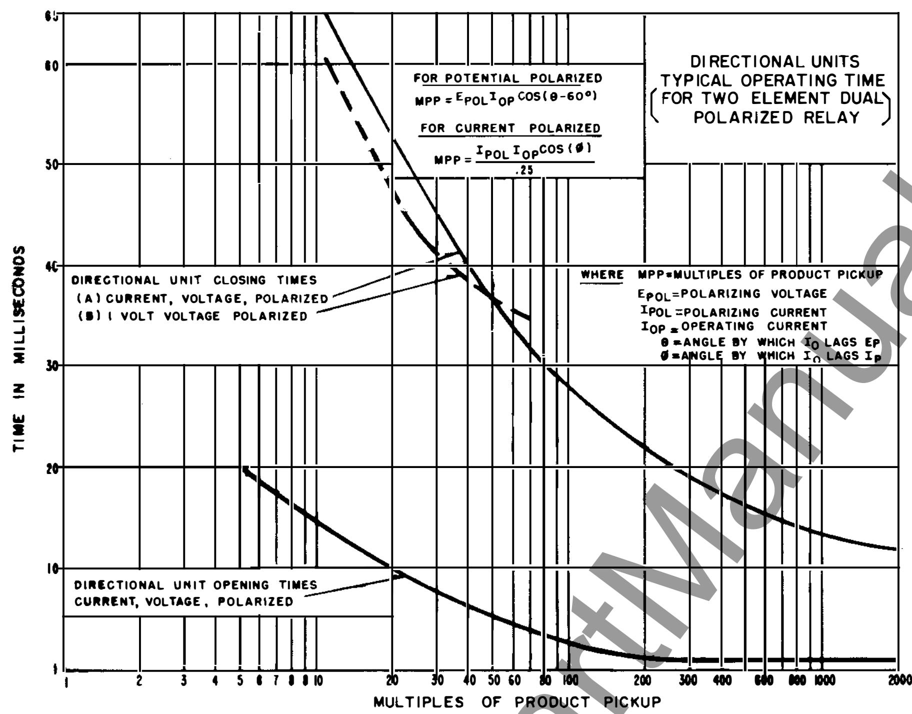
2. Sensitivity – The respective directional units should trip with value of energization and phase angle relationships as indicated in Table 1.

3. Spurious Torque Adjustments – There should be no spurious closing torques when the operating circuits are energized per Table 2 with the polarizing circuits short-circuited for the voltage polarized units and open-circuited for the current polarized units.

Indicating Contactor Switch (ICS)

Close the main relay contacts and pass sufficient d-c current through the trip circuit to close the contacts of the ICS. This value of current should be between 1 and 1.2 amperes. The indicator target should drop freely.

The contact gap should be approximately 5/64" be-



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* *Fig. 5. Typical Operating Times for the Type KRP and KRD (When Potential Polarized) Relays.*

tween the bridging moving contact and the adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously.

ROUTINE MAINTENANCE

All relays should be inspected periodically and the operation should be checked at least once every year or at such other time intervals as may be dictated by experience to be suitable to the particular application.

All contacts should be periodically cleaned. A contact burnisher S#182A836H01 is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact.

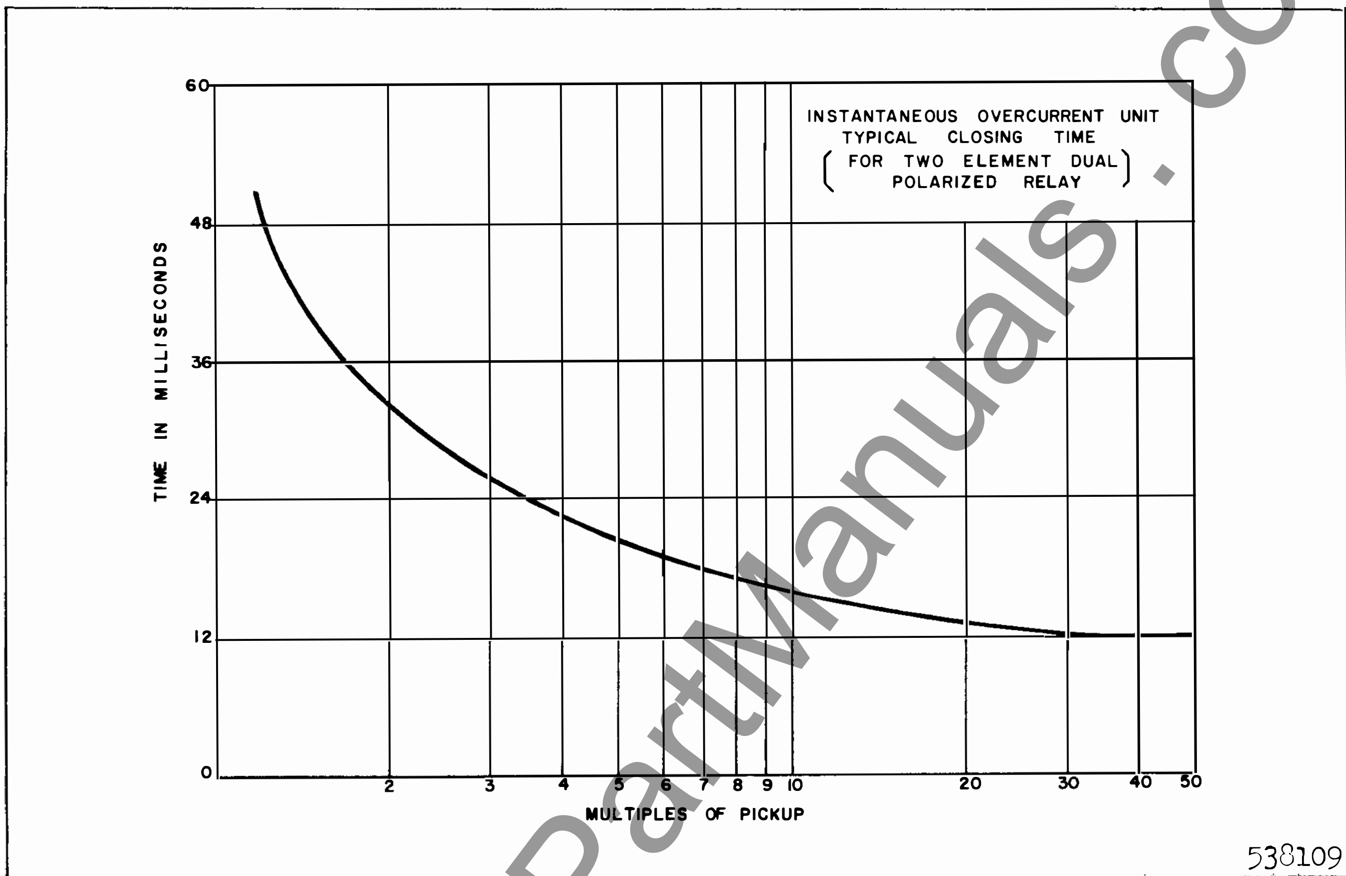
Calibration

Use the following procedure for calibrating the relay if the relay has been taken apart for repairs or the adjustments have been disturbed. This procedure should not be used unless it is apparent that the relay is not in proper working order. (See "Acceptance Check").

Overcurrent Unit (I)

1. The upper pin bearing should be screwed down until there is approximately .025 clearance between it and the top of shaft bearing. The upper pin bearing should then be securely locked in position with the lock nut. The lower bearing position is fixed and cannot be adjusted.

2. The contact gap adjustment for the overcurrent unit is made with the moving contact in the reset position, i.e., against the right side of the bridge. Advance the stationary contact until the contacts just close. Then back off the stationary contact 2/3 of one turn for a gap of approximately .020". The clamp holding the stationary contact housing need not be loosened for the adjustment since the clamp utilizes a spring-type action in holding the stationary contact in position.



* *Fig. 6. Typical Operating Times for the Type KRC and KRD (When Current Polarized) Relays.*

3. The sensitivity adjustment is made by varying the tension of the spiral spring attached to the moving element assembly. The spring is adjusted by placing a screwdriver or similar tool into one of the notches located on the periphery of the spring adjuster and rotating it. The spring adjuster is located on the underside of the bridge and is held in place by a spring type clamp that does not have to be loosened prior to making the necessary adjustments.

Before applying current, block open the normally-closed contact of the directional unit. Insert the tap screw in the minimum value tap setting and adjust the spring such that the contacts will close as indicated by a neon lamp in the contact circuit when energized with the required current. The pick up of the overcurrent unit with the tap screw in any other tap should be within ±5% of tap value.

If adjustment of pick-up current in between tap settings is desired insert the tap screw in the next lowest tap setting and adjust the spring as described. It should be noted that this adjustment results in a slightly different time characteristic curve and burden.

Directional Unit (D)

In the type KRP and KRC relays the directional unit is the lower unit. In the type KRD the directional units are the lower and middle units.

1. The upper bearing screw should be screwed down until there is approximately .025 clearance between it and the top of the shaft bearing. The upper pin bearing should then be securely locked in position with the lock nut.

2. Contact gap adjustment for the directional unit is made with the moving contact in the reset position, i.e., against the right side of the bridge. Advance the right hand stationary contact until the contacts just close. Then advance the stationary contact an additional one-half turn.

Now move in the left-hand stationary contact until it just touches the moving contact. Then back

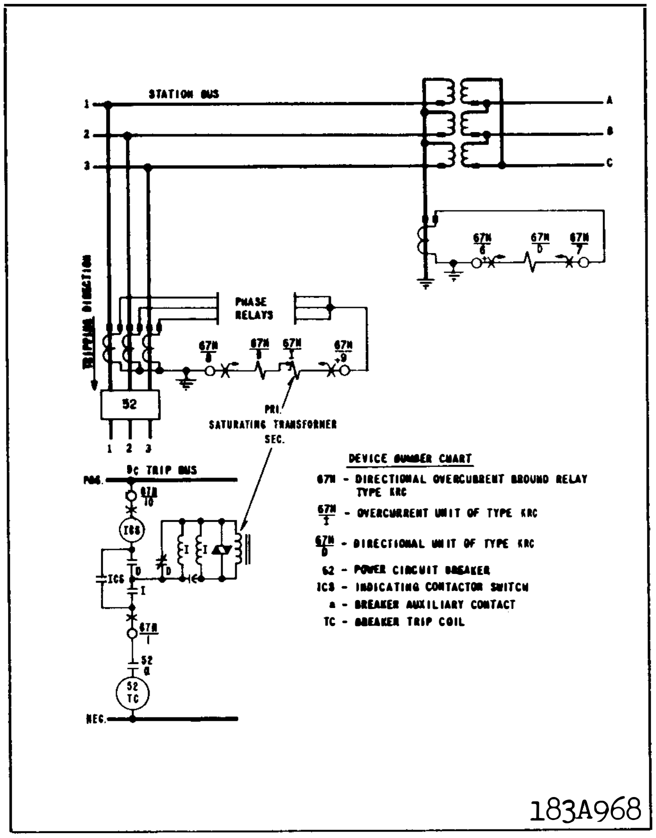


Fig. 7. External Schematic of the Type KRC Relay.

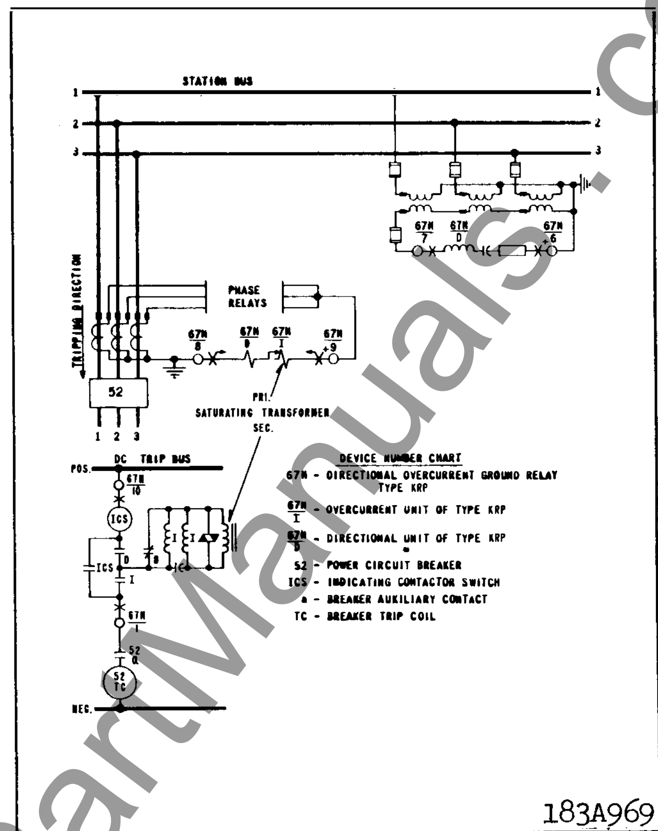


Fig. 8. External Schematic of the Type KRP Relay.

off the stationary contact 3/4 of one turn for a contact gap of .020" to .024". The clamp holding the stationary contact housing need not be loosened for the adjustment since the clamp utilizes a spring-type action in holding the stationary contact in position.

3. Insert tap screw of overcurrent unit in highest tap. The sensitivity adjustment is made by varying the tension of the spiral spring attached to the moving element assembly. The spring is adjusted by placing a screwdriver or similar tool into one of the notches located on the periphery of the spring adjuster and rotating it. The spring adjuster is located on the underside of the bridge and is held in place by a spring type clamp that does not have to be loosened prior to making the necessary adjustments.

The spring is to be adjusted such that the contacts will close as indicated by a neon lamp in the contact circuit when energized with the required current and voltage as shown in Table 1. This table indicates that the spring can be adjusted when the phase angle relationship between the operating circuit and the polarizing circuit is at the maximum torque angle or when the circuit relationship has the operating and polarizing circuits in phase.

4. The magnetic plugs are used to reverse any unwanted spurious torques that may be present when the relay is energized on current alone.

The reversing of the spurious torques is accomplished by using the adjusting plugs in the following manner:

a) Voltage circuit terminals on the voltage polarized relays (KRP and KRD voltage polarized unit) are short-circuited.

b) The polarizing circuit of the current polarized relays (KRC and KRD current polarized unit) are open-circuited.

Upon completion of either "a" or "b", current is applied to the operating circuit terminals as per Table 2.

Plug adjustment is then made per Table II such that the spurious torques are reversed. The plugs are held in position by upper and lower plug clips. These clips need not be disturbed in any manner when making the necessary adjustment.

The magnetic plug adjustment may be utilized to positively close the contacts on current alone. This

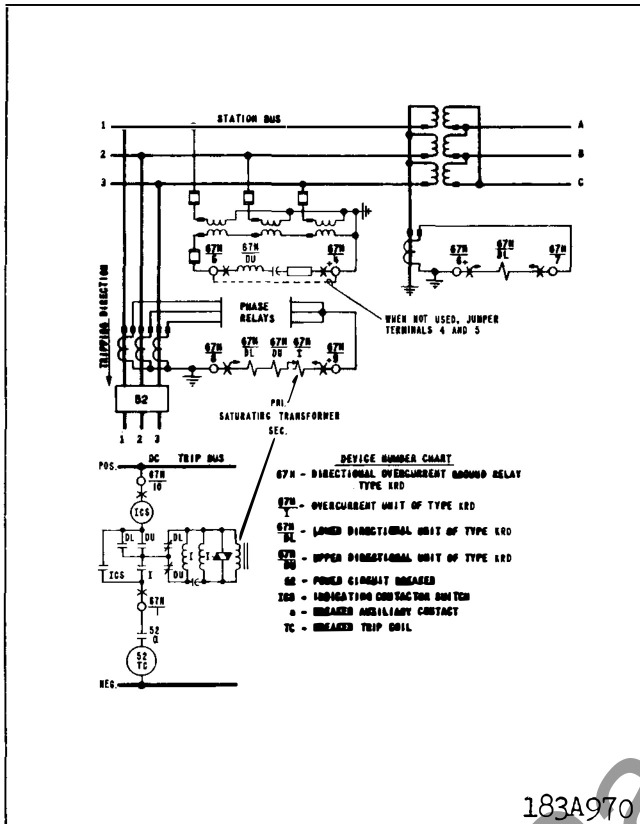


Fig. 9. External Schematic of the Type KRD Relay.

may be desired on some installations in order to insure that the relay will always trip the breaker on zero potential.

Indicating Contactor Switch (ICS)

Adjust the contact gap for approximately 5/64" (-1/64", +0).

Close the main relay contacts and check to see that the relay picks up and the target drops between 1 and 1.2 amperes d-c.

To increase the pickup current remove the molded cover and bend the springs out or away from the cover. To decrease the pickup current bend the springs in toward the cover.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, interchangeable parts can be furnished to the customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data.

RATING OF OVERCURRENT UNIT

RANGE	CONTINUOUS RATING AMPERES	ONE SECOND RATING AMPERES
.5-2	5	100
1-4	8	140
2-8	8	140
4-16	10	200
10-40	10	200

TABLE I

DIRECTIONAL UNIT SENSITIVITY

RELAY TYPE	AMPERE RATING	VALUES FOR MIN. PICKUP τ		PHASE ANGLE RELATIONSHIP
		VOLTS	AMPERES	
KRP KRD (Voltage Unit)	.5-2 1-4 2-8	1	2.0	I lagging V by 60° ττ
		1	4.0	I in-phase with V
	4-16 10-40	1	4.0	I lagging V by 60° ττ
		1	8.0	I in-phase with V
KRC KRD (Current Unit)	.5-2 1-4 2-8		0.5	I_o leading I_p by 40° ττ
			* 0.57	In-phase
	4-16 10-40		1.0	I_o leading I_p by 40° ττ
			* 1.4	In-phase

τ The energization quantities are input quantities at the relay terminals.
ττ Maximum torque angle.

TABLE II

DIRECTIONAL UNIT CALIBRATION

RELAY RATING	CURRENT AMPERES	BOTH PLUGS IN CONDITION	ADJUSTMENT
All Ranges	80	Spurious Torque In Contact Closing Direction (Left Front View)	Right (Front-View) Plug Screwed Out Until Spurious Torque is Reversed.
All Ranges	80	Spurious Torque In Contact Opening Direction (Right Front View) (Contacts remain open)	Left (Front View) Plug Screwed Out Until Spurious Torque is in Contact Closing Direction. Then the plug is screwed in Until Spurious Torque is Reversed.

Short circuit the voltage polarizing circuit and open circuit the current polarizing circuit at the relay terminals before making the above adjustments.

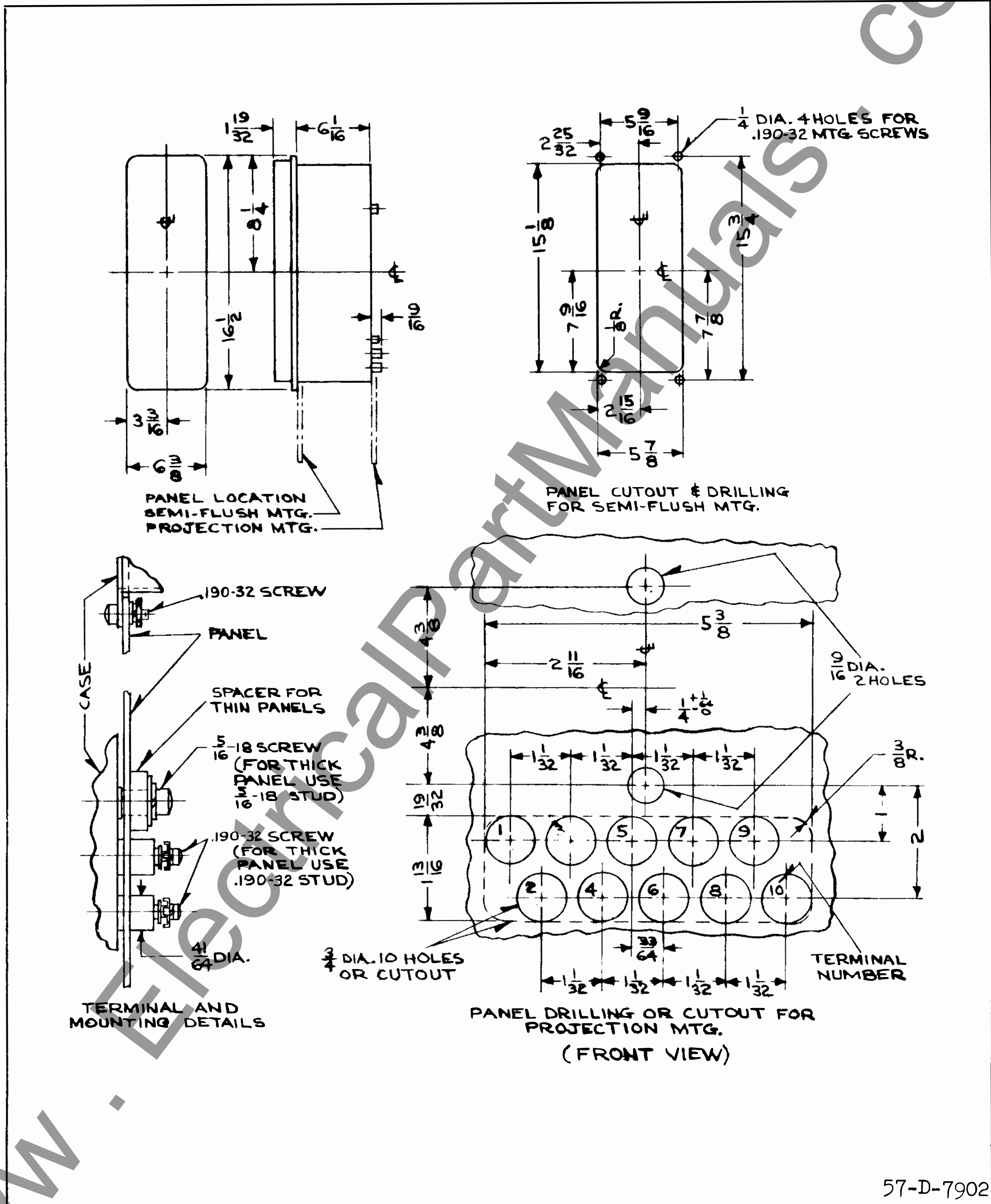


Fig. 10. Outline and Drilling Plan for the KRP, KRC, and KRD Relays in the FT31 Case.

WESTINGHOUSE ELECTRIC CORPORATION

RELAY-INSTRUMENT DIVISION NEWARK, N. J.

Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE KRD-4 DIRECTIONAL OVERCURRENT GROUND RELAY

CAUTION: Before putting relays into service, remove all blocking which may have been inserted for the purpose of securing the parts during shipment, make sure that all moving parts operate freely, inspect the contacts to see that they are clean and close properly, and operate the relay to check the settings and electrical connections.

APPLICATION

The KRD-4 relay is a high speed directional overcurrent relay which is used for the protection of transmission lines and feeder transmission lines and feeder circuits. These relays are dual polarized relays which can be polarized from a potential source, from a local ground source, or from both simultaneously.

They are also used, without modifications to provide directional ground fault protection in the KD-4 carrier relaying scheme. Operation of the relays in connection with the carrier scheme is fully described in I.L. 41-911.

CONSTRUCTION

The type KRD-4 directional overcurrent ground relay consists of a dual polarized directional unit, an instantaneous overcurrent unit, and an indicating contactor switch. The principal parts of the relay and their location are shown in Fig. 1 to 3.

A. DIRECTIONAL UNIT (D)

The directional unit of the KRD-4 consists of an induction cylinder unit, phase shifting network, and a de-coupling network.

1. Induction Cylinder Unit

The cylinder unit is a product type in which torque is produced by the phase relationship of an operating flux and a polarizing flux on an aluminum cylinder supporting a moving contact arm. A contact opening torque or a contact closing torque is produced depending upon the phase relationship between the two fluxes.

The cylinder unit consists of three basic assemblies: an electromagnet assembly, a moving element assembly, and a stationary closing assembly.

The electromagnet assembly consists of an electromagnet, an adjustable magnetic core, two magnetic adjusting plugs, lower bearing pin, and a die-casted aluminum frame. The moving element assembly consists of a spiral spring, contact carrying member, and an aluminum cylinder which is assembled to a molded hub which holds the shaft. The shaft has removable top and bottom jewel bearings. The stationary contact assembly consists of a molded bridge, upper bearing pin, stationary contact housing and spring adjuster is located on the underside of the bridge and is held in place by a spring type clamp. It is attached to the moving contact arm by a spiral spring.

The electromagnet has four poles, two operating poles and two polarizing poles. Each pair of poles are diametrically opposite each other and are excited by series connected coils. (Two sets of series connected coils are used to excite the polarizing poles, one set for current polarizing and the other set for voltage polarizing). The electromagnet is permanently mounted to the frame in such a manner that an air gap exists between the pole faces of the electromagnet and the magnetic core. The aluminum cylinder of the moving element assembly rotates in this air gap on the upper and lower pin bearing.

With the contacts closed, the electrical connection is made through the stationary contact housing clamp, then the moving contact, through the spiral spring out to the spring adjusted clamp.

2. Phase Shifting Network

The phase shifting network consists of a resistor, capacitor and reactor in the polarizing circuit of the directional unit, and a saturable shunt in the operating circuit.

3. De-Coupling Network

The de-coupling network consists of an air gap

SUPERSEDES I.L. 41-137.3
*Denotes change from superseded issue

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transformer, capacitor, reactor, and resistor. Electrically this network is equivalent to the polarizing circuit of the induction cylinder unit and is utilized to minimize the coupling between the current and potential polarized sources.

B. INSTANTANEOUS OVERCURRENT UNIT (I)

The instantaneous overcurrent unit consists of an induction cylinder unit, capacitor, varistor, and a transformer. The components are connected such that a contact closing torque is produced when the current exceeds a specified value.

1. Cylinder Unit

The cylinder unit is similar in construction to the cylinder unit of the directional unit except that all coils are similar. The phase relationship of the two air gap fluxes necessary for the development of torque is achieved by means of a capacitor connected in series with one pair of pole windings.

2. Transformer

The transformer is a saturating type consisting of a tapped primary winding and a secondary winding. A varistor is connected across the secondary winding to reduce the voltage peaks applied to the cylinder unit and phase shifting capacitor.

C. INDICATING CONTACTOR SWITCH (ICS)

The indicating contactor switch is a small d-c operated clapper type device. A magnetic armature to which leaf-spring mounted contacts are attached, is attracted to the magnetic core upon energization of the switch. When the switch closes, the moving contacts bridge two stationary contacts, completing the trip circuit. Also during this operation two fingers on the armature deflect a spring located on the front of the switch, which allows the operation indicator target to drop. The target is reset from outside of the case by a push rod located at the bottom of the cover.

The front spring, in addition to holding the target, provides restraint for the armature and thus controls the pickup value of the switch.

OPERATION

The type KRD-4 relay is connected to the protected transmission line as shown in Fig. 4. In such a connection, the relay operates to disconnect the line for ground faults of a definite magnitude that are flowing in a specified direction.

The directional unit of the relay compares the phase angle between the fault current and the polarizing quantities of the system and either produces a contact closing torque for faults in the trip direction or produces a contact opening torque for faults in the non-trip direction. Relay operation occurs when both the directional unit and the instantaneous overcurrent unit close their contacts. Hence, the fault current must be greater than the tap setting of the overcurrent unit.

For faults in the non-trip direction, a contact opening torque is produced by the directional unit such that the normally closed contact of this unit shorts out a pair of windings on the overcurrent unit. This prevents the overcurrent unit from developing torque to close its contacts. For faults in the trip direction, the directional unit will pickup and remove this short circuit, allowing the overcurrent contact to commence closing almost simultaneously with the directional contact for high speed operation.

CHARACTERISTICS

The relays are available in the following current ranges:

Range	Taps					
0.5-2 Amps.	0.5	0.75	1.0	1.25	1.5	2
1-4	1.0	1.5	2.0	2.5	3.0	4.0
4-16	4.0	6.0	8.0	9.0	12	16
10-40	10	15	20	25	30	40

The tap value is the minimum current required to just close the overcurrent relay contacts. For pickup settings in between taps refer to the section under SETTINGS.

The KRD-4 relay is designed for dual polarizing and can be polarized from a potential source, a local ground source or from both simultaneously. When the relay is potential polarized, the maximum torque of the relay occurs when the operating current lags the polarizing voltage by approximately 65 degrees. When the relay is current polarized, the maximum torque of the relay occurs when the operating current is in phase with the polarizing current.

TIME CURVES

The time curves for the KRD-4 relay are shown in Fig. 5 and 6. Fig. 5 includes three curves which are:

1. Directional Unit opening times for current, voltage, or dual polarized.
2. Directional unit closing times for current, voltage or dual polarized.
3. Directional unit closing time for 5 volts voltage polarized.

Fig. 6 shows the instantaneous overcurrent unit closing time.

The voltage polarized curve (curve A in Fig. 5) begins to deviate from curve A at about 10 volts polarization.

Both the directional unit and the overcurrent unit must operate before the trip circuit can be completed. Hence, the unit which takes the longer time to operate determines when the breaker will be tripped. The overcurrent unit contacts cannot operate until the back contacts of the directional unit open; therefore, the total time for the overcurrent unit to operate is its closing time given in Fig. 6 plus the directional unit's opening time given in Fig. 5. The total closing time for the directional unit is given in Fig. 5. The two examples below will serve to illustrate the use of the curves.

(Example One) definition of symbols are shown on Fig. 5.

let: I_{pol} = 1.5 amp.

I_{op} = 3 amp

tap value (T) = 0.5 amp.

$\emptyset = 0°$

for a current polarized relay:

$$MMP = \frac{I_{op} I_{pol} \cos \emptyset}{0.25}$$

$$MMP = \frac{(3)\ (1.5)}{0.25} = 18$$

Entering the curves in Fig. 5 at multiples of product pickup of 18 the directional unit opening time is 4 ms, and the closing time for this unit is 33 ms.

For the overcurrent unit:

$$\text{multiples of pickup} = \frac{I_{op}}{T}$$

$$= \frac{3}{0.5} = 6$$

Entering the curve in Fig. 6 at multiples of pickup equal to 6 the closing time for the overcurrent is 14 ms. However, the total operating time for the overcurrent unit is 14 plus 4 ms, which is the opening time of back contacts of the directional unit, or 18 ms total operating time for the overcurrent unit. The total operating time for the directional unit is 33 ms; and since this is the longest time, 33 ms is the total operating time of the relay.

(Example Two)

let: I_{pol} = 15 amp

I_{op} = 25 amp

T (tap) = 1 amp.

$\emptyset = 0$

$$MMP = \frac{I_{op} I_{pol} \cos \emptyset}{0.25}$$

$$MMP = 1500$$

referring to Fig. 5 the directional unit closing time is 8 ms, and the opening time of its back contacts is 3 ms. The total operating time for the directional unit is 8 ms.

For the overcurrent unit:

$$\text{multiples of pick up} = \frac{I_{op}}{T}$$

$$= 25$$

referring to Fig. 6 the overcurrent unit contact closing time is 10 ms. Therefore, the total operating time for this unit is 10 + 3 ms or 13 ms. In this case the total operating time of the relay is 13 ms.

Trip Circuit

The main contacts will safely close 30 amperes at 250 volts d-c and the seal-in contacts of the indicating contactor switch will safely carry this current long enough to trip a circuit breaker.

The indicating contactor switch has a pickup of approximately 1 ampere. Its d-c resistance is 0.1 ohms.

Cylinder Unit Contacts

The moving contact assembly has been factory adjusted for low contact bounce performance and should not be changed.

The set screw in each stationary contact has been shop adjusted for optimum follow and this adjustment should not be disturbed.

TABLE I

DIRECTIONAL UNIT SENSITIVITY

Polarizing Quantity	Values for Min. Pickup		Phase Angle Relationship
	Volts	Amperes	
VOLTAGE	1	0.6	I lagging V by 65°
	1	1.4	I In Phase with V
CURRENT		0.5	In-phase

The energization quantities are input quantities at the relay terminals. Maximum torque angle.

TABLE II

DIRECTIONAL UNIT CALIBRATION

Relay Rating	Current Amperes	Both Plugs In Condition	Adjustment
All Ranges	80	Spurious torque in contact closing direction (left front view)	Right (front view Plug Screwed out until spurious torque is reversed.
All Ranges	80	Spurious torque in contact opening direction (Right front view) (Contact remain Open)	Left (front view) Plug screwed out until spurious torque is in contact closing directions. Then the plug is screwed in until spurious torque is reversed.

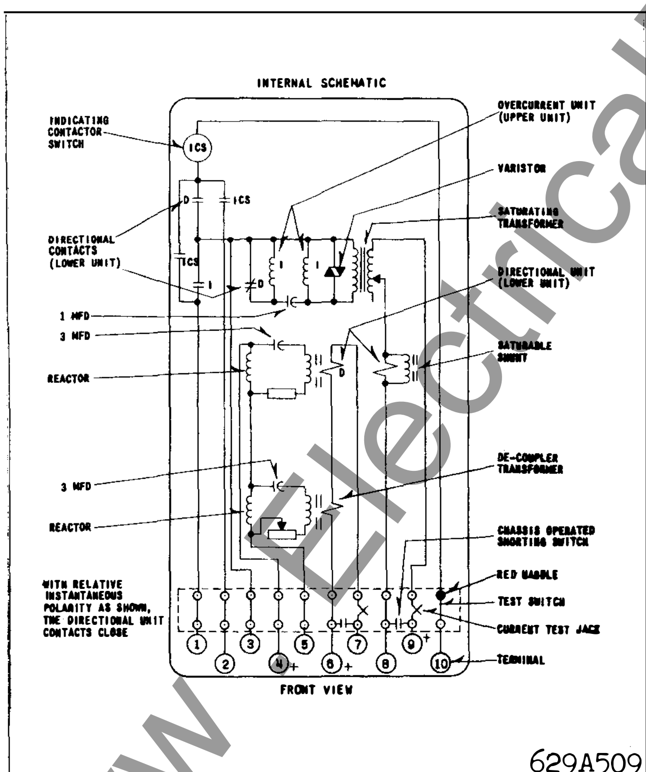

Fig. 3. Internal Schematic of the Type KRD-4 Relay in the Type FT31 Case.

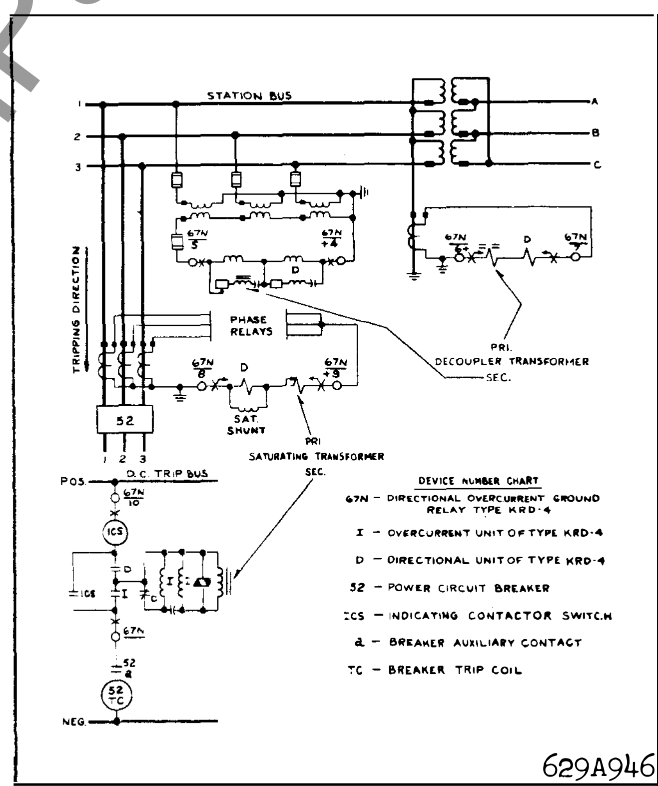

Fig. 4. External Schematic for the Type KRD-4 Relay.

SETTINGS

Overcurrent Unit (I)

The only setting required is the pickup current setting which is made by means of the connector screw located on the tap plate. By placing the connector screw in the desired tap, the relay will just close its contacts at the tap value current.

If adjustment of pick-up current in between tap settings is desired insert the tap screw in the next lowest tap setting and adjust the spring as described. It should be noted that this adjustment results in a slightly different time characteristic curve and burden.

For carrier relaying the carrier trip overcurrent unit located in the type KRD-4 relay should be set higher than the carrier start overcurrent unit located in the type KA-4 relay at the opposite end of the line.

CAUTION: Since the tap block connector screw carries operating current, be sure that the screw is turned tight.

In order to avoid opening the current transformer circuits when changing taps under load, connect the spare tap screw in the desired tap position before removing the other tap screw from the original tap position.

ENERGY REQUIREMENTS

BURDEN DATA OF OPERATING CURRENT CIRCUIT - 60 CYCLES

AMPERE RANGE	TAP	VA AT TAP VALUE	P.F. ANGLE Ø	VA AT 5 AMPS *	P.F. ANGLE Ø
	.5	.23	54°	47	52°
	.75	.52	54°	36	52.5°
	1.0	.94	54°	31	53°
.5-2	1.25	1.56	54°	28	53.5°
	1.5	2.17	54°	26.5	54°
	2.0	3.88	54°	24	55°
	1.0	1.3	52°	31.5	51°
	1.5	2.85	52°	27.3	51.5°
*	2.0	5.2	52°	25.0	52°
1-4	2.5	7.75	52°	24.2	52.5°
	3.0	11.4	52°	23.8	53
	4.0	10.6	52°	23.3	53.5°
	4	5.6	43°	610†	53°
	6	10.8	46°	570†	54°
	8	17.6	47°	560†	54°
4-16	9	22.5	48°	550†	55°
	12	39.5	50°	550†	56°
	16	69	52°	550†	56°
	10	28	49°	545†	50°
	15	61	51°	540†	51°
10-40	20	108	53°	535†	52°
	25	169	54°	530†	53°
	30	252	56°	525†	53°
	40	432	57°	525†	53°

† VA at 50 Amperes.

DIRECTIONAL UNIT POLARIZING CIRCUIT BURDEN

CIRCUIT	RATING	VOLT AMPERES△	POWER FACTOR ANGLE Ø
Current	230†† amperes	1.20	3° Lag
Voltage	208††† volts *	21.0	28° Lead

Ø Degrees current leads or lags voltage at 120 volts on voltage polarized units and 5 amperes on current polarized units.

△ Burden of voltage polarized unit taken at 120 volts. Burden of current polarized units taken at 5 amperes.

†† One second rating.

††† 30 second rating. The 10 second rating is 345 volts. The continuous rating is 120 volts.

Directional Unit (D)

No setting is required.

INSTALLATION

The relays should be mounted on switchboard panels or their equivalent in a location free from dirt, moisture, excessive vibration and heat. Mount the relay vertically by means of the two mounting studs for projection mounting or by means of the four mounting holes on the flange for the semi-flush mounting. Either of the studs or the mounting screws may be utilized for grounding the relay. The electrical connections may be made directly to the terminals by means of screws for steel panel mounting or to terminal studs furnished with the relay for thick panel mounting. The terminal studs may be easily removed or inserted by locking two nuts on the studs and then turning the proper nut with a wrench.

For detailed information, refer to I.L. 41-076.

ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory. Upon receipt of the relay, no customer adjustments, other than those covered under "SETTINGS," should be required.

Acceptance Check

The following check is recommended to insure that the relay is in proper working order.

Overcurrent Unit (I)

1. Contact Gap - The gap between the stationary and moving contacts with the relay in the de-energized position should be approximately .020."
2. Minimum Trip Current - The normally-closed contact of the directional unit should be blocked open when checking the pick-up of the overcurrent unit.

   The pick-up of the overcurrent unit can be checked by inserting the tap screw in the desired tap hole and applying rated tap value current. The contact should close with ±5% of tap value current.

Directional Unit (D)

1. Contact Gap - The gap between the stationary contact and moving contact with the relay in the de-energized position should be approximately .020."
2. Sensitivity - The respective directional units should trip with value of energization and phase angle relationships as indicated in Table 1.
3. Spurious Torque Adjustments - Three should be no spurious closing torques when the operating circuits are energized per Table 2.
4. Coupling - Apply 20 amperes to terminals 6 and 7. Measure voltage across terminals 4 and 5. Should be less than 20 volts.

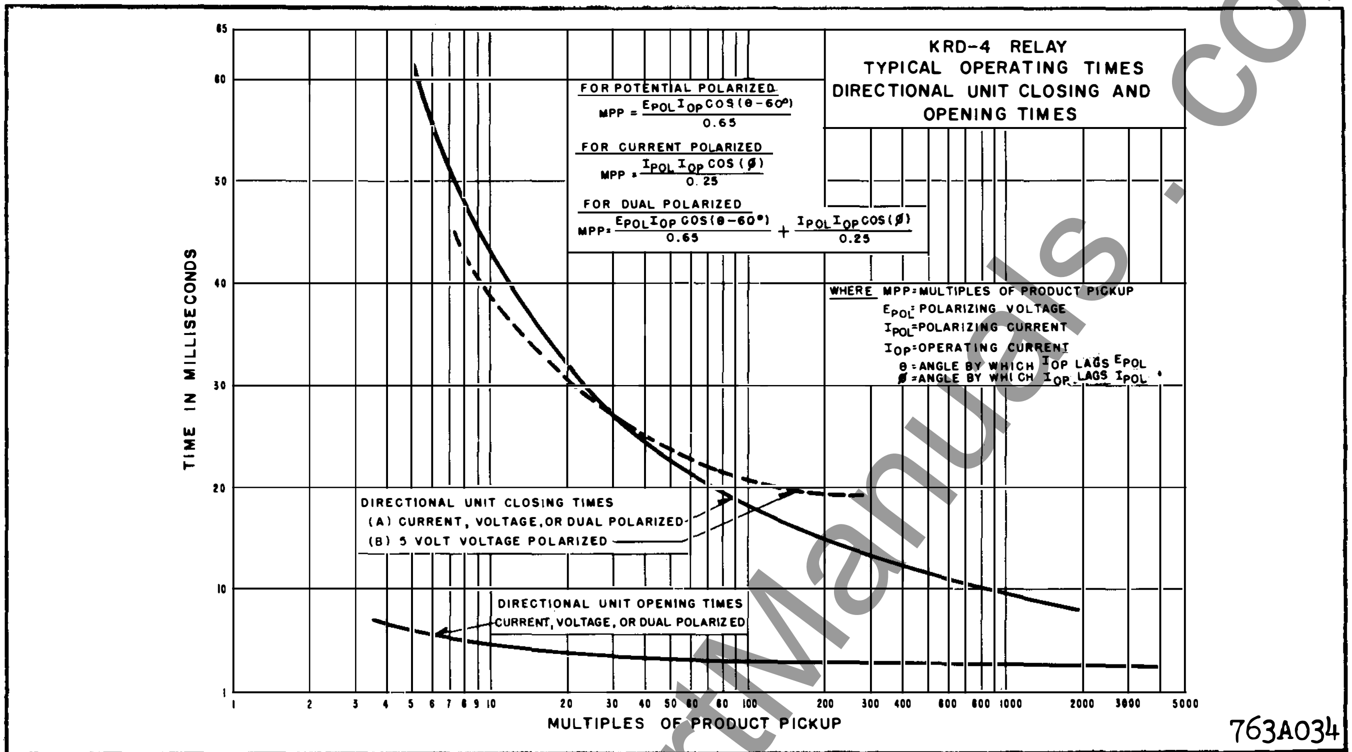

Fig. 5. Typical Time Curves for the Directional Unit.

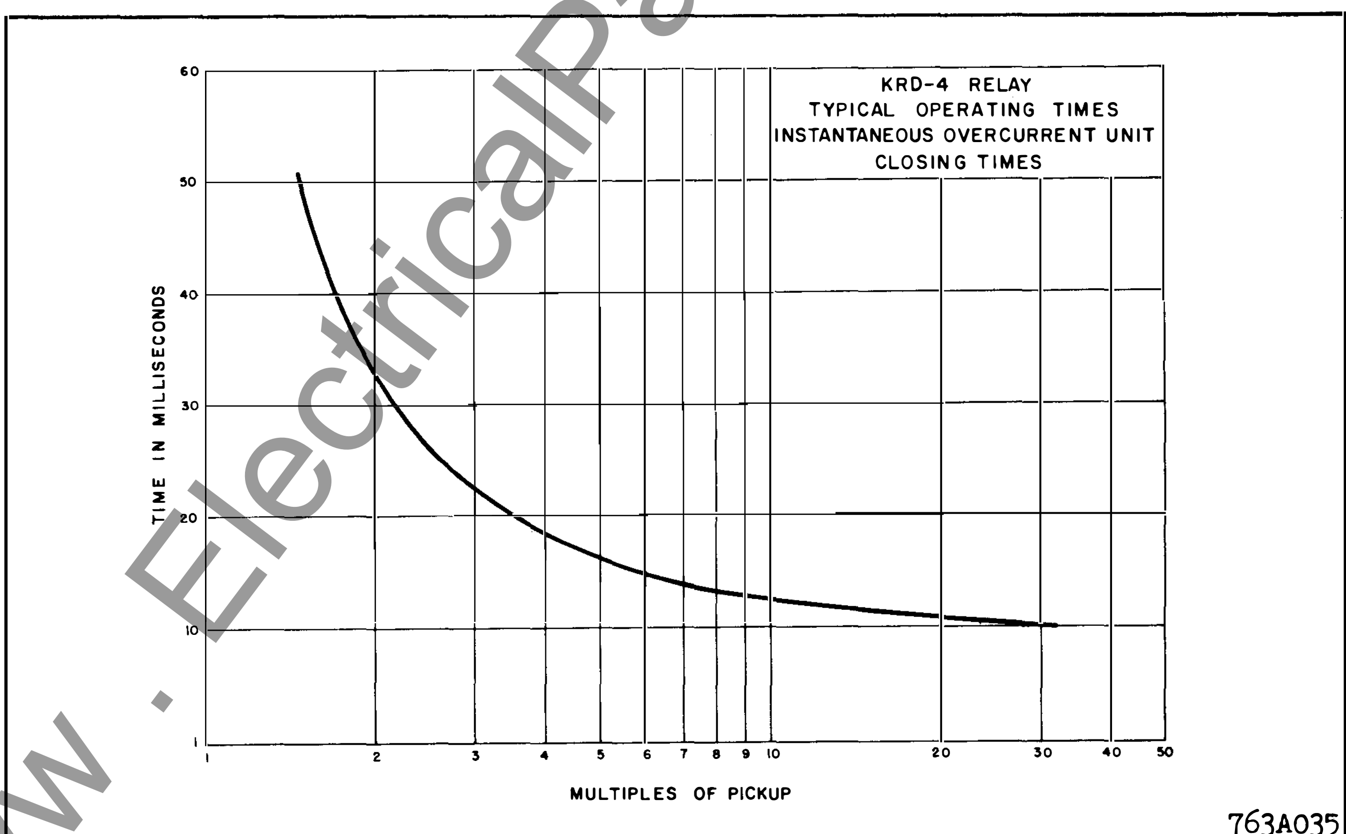

Fig. 6. Typical Time Curves for the Instantaneous Overcurrent Unit.

Indicating Contactor Switch (ICS)

Close the main relay contacts and pass sufficient d-c current through the trip circuit to close the contacts of the ICS. This value of current should be between 1 and 1.2 amperes. The indicator target should drop freely.

The contact gap should be approximately 5/64" between the bridging moving contact and the adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously.

ROUTINE MAINTENANCE

All relays should be inspected periodically and the operation should be checked at least once every year or at such other time intervals as may be dictated by experience to be suitable to the particular application.

All contacts should be periodically cleaned. A contact burnisher S#182A836H01 is recommended for this purpose. The use of abrasive material for cleaning is not recommended because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact.

Calibration

Use the following procedure for calibrating the relay if the relay has been taken apart for repairs or the adjustments have been disturbed. This procedure should not be used unless it is apparent that the relay is not in working order. (See "Acceptance Check").

Overcurrent Unit (I)

1. The upper pin bearing should be screwed down until there is approximately .025 clearance between it and the top of shaft bearing. The upper pin bearing should then be securely locked in position with the lock nut. The lower bearing position is fixed and cannot be adjusted.

2. The contact gap adjustment for the overcurrent unit is made with the moving contact in the reset position, e.g., against the right side of the bridge. Advance the stationary contact until the contacts just close. Then back off the stationary contact 2/3 of one turn for a gap of approximately .020". The clamp holding the stationary contact housing need not be loosened for the adjustment since the clamp utilizes a spring-type action in holding the stationary contact in position.

3. The sensitivity adjustment is made by varying the tension of the spiral spring attached to the moving element assembly. The spring is adjusted by placing a screwdriver or similar tool into one of the notches located on the periphery of the spring adjuster and rotating it. The spring adjuster is located on the underside of the bridge and is held in place by a spring type clamp that does not have to be loosened prior to making the necessary adjustments.

Before applying current, block open the normally-closed contact of the directional unit. Insert the tap screw in the minimum value tap setting and adjust the spring such that the contacts will close as indicated by a neon lamp in the contact circuit when energized with the required current. The pick up of the overcurrent unit with the tap screw in any other tap should be within ±5% of tap value.

Directional Unit (D)

1. The upper bearing screw should be screwed down until there is approximately .025 clearance between it and the top of the shaft bearing. The upper pin bearing should then be securely locked in position with the lock nut.

2. **Contact Gap.** Adjustment for the directional unit is made with moving contact in the reset position, i.e., against the right side of the bridge. Advance the right hand stationary contact until the contacts just close. Then advance the stationary contact an additional one-half turn.

Now move the in the left-hand stationary contact until it just touches the moving contact. Then back off the stationary contact 2/3 of one turn for a contact gap of approximately .020". The clamp holding the stationary contact housing need not be loosened for the adjustment since the clamp utilizes a spring-type action in holding the stationary contact in position.

3. **Sensitivity.** Insert tap screw of overcurrent unit in highest tap. The sensitivity adjustment is made by varying the tension of the spiral spring attached to the moving element assembly. The spring is adjusted by placing a screwdriver or similar tool into one of the notches located on the periphery of the spring adjuster and rotating it. The spring adjuster is located on the underside of the bridge and is held in place by a spring type clamp that does not have to be loosened prior to making the necessary adjustments.

The spring is to be adjusted such that the contacts will close with .5 amperes flowing into terminal 6 and out terminal 8 with terminals 7 and 9 jumped together.

4. **De-Coupling Adjustment.** Connect high resistance, low reading voltmeter across terminals 4 and 5. Pass 80 amperes into terminals 6 and 7 and adjust top left hand resistor (front view) until a minimum voltage is obtained. Use care not to overheat relay during test.

5. **Core Adjustment.** Apply 10 amperes to terterminals 8 and 9 with all other terminals open circuited. Adjust core such that the contacts remain open. The core can be adjusted by the use of a screwdriver in the slots in the bottom of the cylinder unit.

6. **Plug Adjustment.** Apply current to terminals 8 and 9 with all other terminals open circuited. Plug adjustment is then made per Table II such that the spurious torques are reversed. The plugs are held in position by upper and lower plug clips. These clips need not be disturbed in any manner when making the necessary adjustment.

Indicating Contact Switch (ICS)

Adjust the contact gap for approximately 5/64" (-1/64", +0).

Close the main relay contacts and check to see that the relays pick up and the target drops between 1 and 1.2 amperes d-c.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, interchangeable parts can be furnished to the customers who are equipped for doing repair work. When ordering parts always give the complete nameplate data.

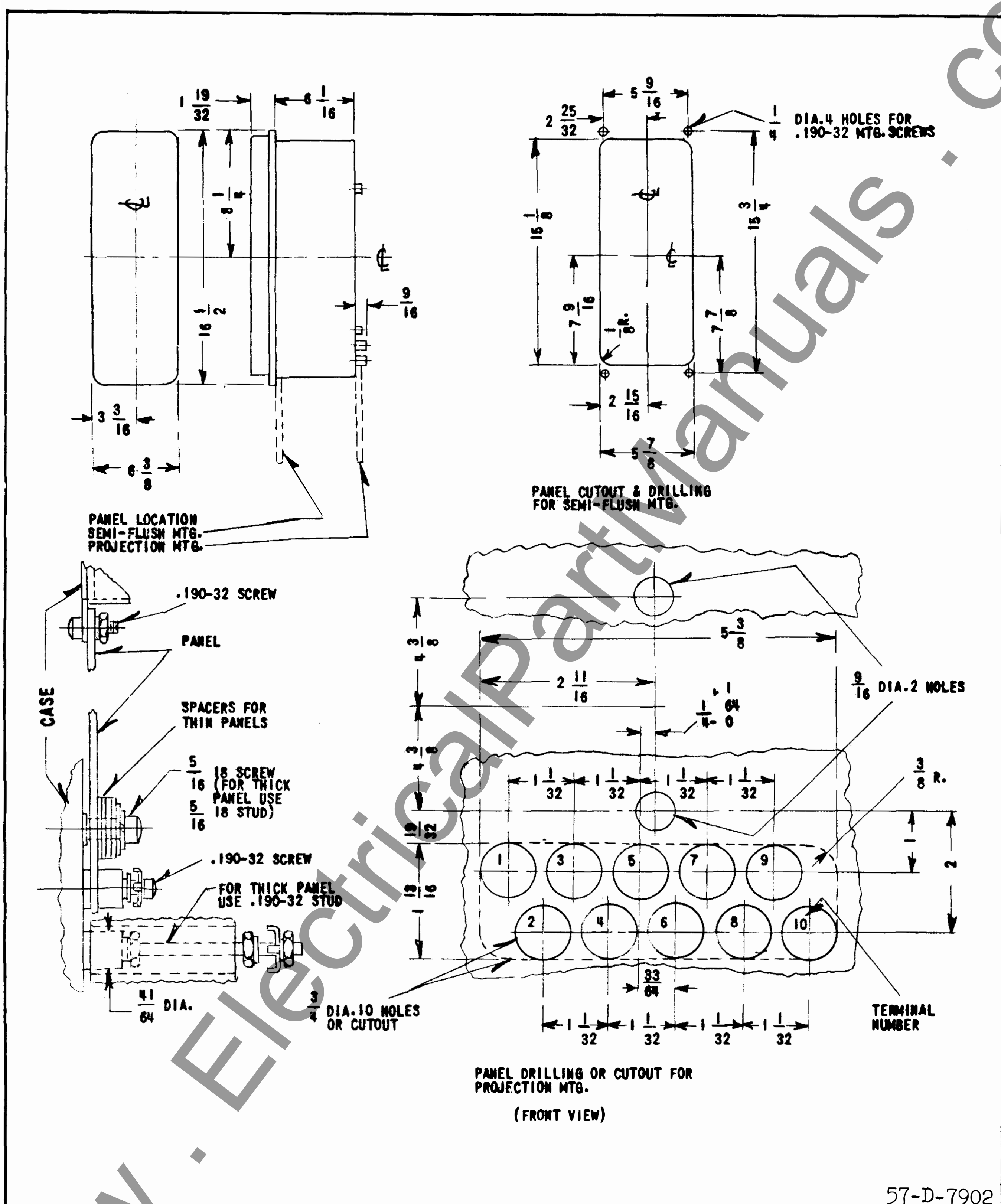

Fig. 7. Outline and Drilling Plan for the Type KRD-4 Relay in the FT31 Case.

TYPE KD-4 and KD-41 COMPENSATOR DISTANCE RELAY (1.1-30 OHMS)

This supplementary I.L. covers special type of KD-4 and KD-41 relays that have 1.1-30 ohms reach.

Application - the same as per I.L. 41-491.4A

Construction - the same as per I.L 41-491.4A, except compensator taps are marked 1.31 - 1.74 - 2.18 - 3.05 - 4.35 - 6.1 - 8.7 ohms.

Operation - the same as per I.L 41-491.4A

Characteristics - the same as per I.L. 41-491.4A, except:

Sensitivity KD-4 Phase-to-Phase unit - the same as per I.L. 41-491.4A, except minimum fault current for the correct directional sense should be not less than 0.025 relay amperes with an ohm setting of 8.7 ohms.

Sensitivity KD-4 3 Phase unit - the same as per I.L. 41-491.4A, except with T=8.7 ohms the three phase unit will directionally operate for faults which produce 2 volts line to line and 0.666 amperes at relay terminals. Sensitivity with 2 volts line-to-line for any tap is defined by the following equation: $I = \frac{5.8}{T}$ Amperes.

Distance Characteristic KD-41, 3 Phase Unit - The same as per I.L. 41-491.4A. The forward reach of the unit varies from 102 percent of tap value for a T setting of 8.7 and 75 degrees to 115 percent of tap value at 95 degrees for a T setting of 1.31 ohms. Fig. 11 is still applicable.

Sensitivity KD-41, 3 Phase unit - The impedance curve shown in Fig. 9 is still applicable. This unit will operate to close the left hand contact on current only for a minimum of 3 or less amperes with T set for 8.7 ohms and for 7.5 amperes or less for T set for 1.31 ohms.

Time Curves and Burden Data -
Operating Time - Fig. 12 is no longer applicable. See enclosed dwg. 763A054 for KD-4 relay. Fig. 13 and 14 apply exactly to 3 phase unit, as shown; phase-to-phase unit times for contact closing are slower for 1.1-30 ohms relay than for .75-20 ohms relay by 20 percent; the contact opening time is the same for both relays.

Burden Data - Voltage Burden data shown on Fig. 15 of I.L. 41-491.4A applies

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to the 1.1-30 ohms relay, except the current burden shown as per dwg. 7?2A?69 does not apply. Use the dwg. 763A050 for correct burden for KD-41 and KD-4 relays. Fig. 16 dwgs. do not apply to the 1.1-30 ohms relay, use dwgs. 763A051, 763A052, 763A053, and 763A050 instead.

Setting Calculations - as per I.L. 41-491.4A, except use special Table I developed for 1.1 to 30 ohms relay. Using the given example and the new Table I relay settings, we find that the nearest value to 7.77 ohms is 7.80 ohms, and we read from Table I: S = 1
T = 8.7
M = +.12

Settings, Installations, External Connections and Switchboard Testing are the same as per I.L. 41-491.4A.

Receiving Acceptance - the same as per I.L. 41-491.4A, except:
Set T, T_A, T_B, and T_C for 6.1

" S, S_A, S_C for 1

" M, M_A and M_C for +0.15

For Part B the pickup current should be 3.25 - 3.50 amperes for KD-4 and 3.15 - 3.40 amperes for KD-41.

For Parts E and F the current should be 2.75 - 2.92 amps.

Routine Maintenance - as per I.L 41-491.4A

Repair Calibration - as per I.L 41-491.4A except:

Autotransformer Check - as per I.L. 41-491.4A except the voltage drops for M_A and M_C taps to terminal 8 should read - 66.6 - 68.6 - 74.6 - 78.6 volts. (± 1 volt)
This voltage is computed as follows: 100 x 2/3 (1 + the sum of value between R-lead and the tap being measured)
Example: 100 x 2/3 (1 + .03 + .09 + .06) = 78.6 volts.

Distance Unit Calibration - the taps on the front should be set as follows:
T, T_A, T_B, (twice), and T_C on 6.1

S, S_A, and S_C set on 1.0

" L " for M, M_A, and M_C set in the top position

" R" for M, M_A, and M_C set on ".03"

so that M = (.06 + .09) = .15 between "R" and "L"

I. Three Phase Unit - As per I.L. 41-491.4A except spring restraint should be adjusted so that contact closes at following voltages:
Voltages V_{1F2F} and V_{2F3F} = 10 volts

Current to trip KD-4 1.22 amps.
for KD-41 1.25 amps.

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II. Phase to Phase Unit - As per I.L 41-491.4A, except spring restraint should be adjusted where voltage V_{1F}, V_{2F}, and V_{2F3F} are set for 5 volts.

III. Compensator Check - As per I.L. 41-491.4A, except the voltages should read as follows:
Where: "T" - taps are set for "8.7" - ohms
Voltage from M to fixed end of R_3 should read $V_C = 1.5\ IT\left(\frac{\sin\theta}{\sin 75°}\right)$

$= 135.2$ volts ($\theta=90°$)

Voltage from "M_A" to fixed end of R_{2A}
Voltage from "M_C" to fixed end of R_{2C}
$V_C = 3/4\ IT\left(\frac{\sin\theta}{\sin 75°}\right) = 120$ Volts ($\theta=90°$)

IV. Overall Check - As per I.L. 41-491.4A except use following pickup limits for 3-phase unit.

V_{1F2F} and V_{2F3F}	I Min.	I Max.
10 volts	-	1.22 a. for KD-4 1.25 a. for KD-41
30 volts	3.26	3.42 a. KD-4 3.50 a. KD-41
70 volts	7.45	7.7 a. both relays

Limits for Phase-to-Phase unit

Test #	Volts	Amperes (for KD-4 and KD-41)	
	V_{1F2F}	I Min.	I Max.
5, 6, 7,	5. 30. 70.	.48 2.80 6.6	.52 3.00 6.75

Reference Dwg.

Instruction Leaflet	I.L. 41-491.4A	Potential Burden	763A051 763A052 763A053
Internal Schematic	762A546 629A587		
Operating Curves	763A054	Current Burden	763A050

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RELAY SETTINGS FOR KD-4 and KD-41

	S = 1							S = 2		S = 3		" M "		LEAD CONNECTIONS		
T	1.31	1.74	2.18	3.05	4.35	6.1	8.7	6.1	8.7	6.1	8.7	+M	-M	"L" LEAD	"R" LEAD	
	1.11	1.47	1.84	2.58	3.69	5.17	7.38	-	14.7	-	22.1	+.18		.06	0	"L" over "R"
	1.14	1.51	1.89	2.65	3.79	5.30	7.56	-	15.1	-	22.7	+.15		.06	.03	
	1.17	1.55	1.95	2.72	3.88	5.45	7.80	10.90	15.5	-	23.3	+.12		.09	0	
	1.20	1.60	2.00	2.80	3.99	5.60	8.00	11.2	16.0	-	23.9	+.09		.09	.03	
	1.23	1.64	2.06	2.87	4.10	5.75	8.20	11.50	16.4	-	24.6	+.06		.06	.09	
	1.27	1.69	2.12	2.96	4.23	5.92	8.45	11.80	16.9	-	25.4	+.03		.03	0	
	1.31	1.74	2.18	3.05	4.35	6.10	8.7	12.2	17.4	-	26.1	0	0	0	0	
	1.35	1.80	2.24	3.14	4.48	6.30	9.00	12.6	17.9	-	26.9		-.03	0	.03	"R" over "L"
	1.39	--	2.32	3.24	4.63	6.50	9.27	13.0	18.5	-	27.8		-.06	.09	.06	
	1.44	--	2.40	3.35	4.78	6.72	9.55	13.4	19.1	-	28.7		-.09	.03	.09	
	--	--	2.48	3.46	4.94	6.94	9.90	13.9	19.7	-	29.7		-.12	0	.09	
	--	--	2.56	3.58	5.12	7.18	10.20	14.4	20.4	21.5	30.7		-.15	.03	.06	
	--	--	--	3.72	-	-	10.60	14.9	21.2	-	31.8		-.18	0	.06	